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U. S. DEPARTMENT OF AGRICULTU

BUREAU OF PLANT INDUSTRY.

B. T. GALLOWAY, *Chief of Bureau.*

BULLETINS OF THE BUREAU OF P INDUSTRY NOS. 192 TO 197, INCLUSIVE, 1910-1911.

VOLUME XXV.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 192.

B. T. GALLOWAY, *Chief of Bureau.*

DROUGHT RESISTANCE OF THE OLIVE IN THE SOUTHWESTERN STATES.

BY

SILAS C. MASON,

ARBORICULTURIST, CROP PHYSIOLOGY AND BREEDING INVESTIGATIONS.

ISSUED JANUARY 17, 1911.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1911.

BUREAU OF PLANT INDUSTRY.

Chief of Bureau, BEVERLY T. GALLOWAY.
Assistant Chief of Bureau, G. HAROLD POWELL.
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., July 30, 1910.

SIR: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 192 of the special series of this Bureau the accompanying manuscript, entitled "Drought Resistance of the Olive in the Southwestern States." This paper was prepared by Prof. Silas C. Mason, Arboriculturist in Crop Physiology and Breeding Investigations, and has been submitted by Mr. Walter T. Swingle, Physiologist in Charge, with a view to its publication.

The data upon which the paper is based were obtained from the study of olive plantations made in Arizona and California, started under irrigation, but afterwards, through the failure of the water supply, left to their fate.

While most fruit trees and vines planted under similar conditions soon perished, the olive trees have survived and made considerable growth, showing themselves to be true desert plants having marked drought-resistant characters.

So strong is this characteristic in the case of some of the varieties of olives grown for oil that it is considered desirable to investigate the possibility of olive culture for oil production in those areas in the Southwest having favorable conditions as to temperature and soil, but with a rainfall not heretofore believed to be sufficient for crop production. At the same time those who desire to experiment should be warned not to plant extensively until the possibilities of fruit production in any particular region have been thoroughly investigated.

With the enactment and enforcement of the Pure Food Law the production of olive oil in the Western States is now on a much different footing from that of a few years ago. Where large quantities of cheap adulterants and substitutes were then sold as pure olive oil, now the olive grower has a market for his product on its merits. With the better prices now prevailing, there seems to be encouragement for a considerable extension of the oil-olive industry.

Mr. Thomas H. Kearney has published a bulletin in this se entitled "Dry-Land Olive Culture in Northern Africa," descri the methods pursued in dry-land olive culture in southern Tu methods which are now being tested in this country by Prof. S Mason and Mr. Kearney in cooperation.

Respectfully,

G. H. Powell,
Acting Chief of Burea

Hon. James Wilson,
Secretary of Agriculture.

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B. P. I.—596.

DROUGHT RESISTANCE OF THE OLIVE IN THE SOUTHWESTERN STATES.

INTRODUCTION.

Olive culture in the United States has passed through many vicissitudes. Hence, for the fullest knowledge of this industry to-day we should study not only those cases where olive planting has been a financial success, but the frequent instances where a more or less successful growth of olive trees has been obtained without a remunerative production of fruit. The olive tree may maintain life and even make considerable growth under conditions of drought and heat so severe that only the most hardy types of desert trees are able to survive them, yet the margin between such a purely vegetative growth and the production of fruit in remunerative quantities may be a very wide one, so wide that to invest money in the planting and care of olive trees on a commercial scale under such conditions would be sheer folly.

Again, it may occur that one olive grove is producing bountifully while another near by, under substantially the same conditions as to temperature, rainfall, and soil may give but a scant return. Here the choice of varieties, the distance of planting, and the methods of culture and pruning, factors all within the control of the grower, may be quite sufficient to explain the difference between success and failure.

In fact with any given example of olive trees which do not fruit, especially if they are distant from productive trees for comparison, only the closest study and thorough experimentation can determine how narrow the margin may be between their present conditions and those of profitable fruit production.

When any plant of economic value is found to possess great ability to resist drought or heat that fact in itself becomes a matter worth close investigation. How does it obtain its supply of moisture? By means of deeply penetrating roots or of superficial roots exploring great areas? Has it some provision for the storage of moisture in time of surplus? Does it possess peculiarities of stem or leaf structure by which the small moisture supply is conserved to the utmost and the living cells insulated and protected in the most effecti-

manner against the desiccating effects of dry air and intense heat? We may even inquire whether its cycle of growth in relation to the seasons does not undergo an adjustment adapting itself to periods of drought and rainfall.

The present bulletin is an attempt to answer such questions in relation to the olive, and the material upon which it is based has been furnished by a number of plantations of olives made in the more arid parts of Arizona and California, where through failure of the irrigation systems the trees were thrown on their own resources. It is noteworthy that in all such cases where besides olives other fruit trees were planted, few of the olives died and almost without exception all other fruit trees perished.

DRY-LAND OLIVE INVESTIGATIONS.

In the writer's study of the possibilities in dry-land tree growth in southern Arizona and southern California his attention has been called to several cases of abandoned plantations where, along with other fruit and ornamental trees, considerable blocks of olives had been planted. With the failure of the irrigation canals and the consequent cessation of care and culture of the trees, almost all kinds died.

The survival of the olives, and not only their survival but continued growth and luxuriant appearance, was so notable a feature as to attract the attention of observing ranchmen of the vicinity, for it must be kept in mind that these were localities where irrigation was not simply a convenience, but an absolute necessity to the growing of every crop at present known to them.

The examples given below showing not the results of careful test and experimentation but results obtained unwittingly and in the face of disaster seem worthy of careful record when studied in the light of the remarkable dry-land olive culture in Tunis, for the first time brought to the attention of this country by Mr. Thomas H. Kearney,[a] of the Bureau of Plant Industry.

EXAMPLES OF DROUGHT RESISTANCE OF THE OLIVE IN THE UNITED STATES.

AN ABANDONED OLIVE GROVE AT CASA GRANDE, ARIZ.

The first of the abandoned plantations noted was that known as the Bogart-Degolia ranch, 2 miles south of Casa Grande station in Pinal County, Ariz. (See fig. 1.) The altitude of the station is about 1,396 feet, and the olive orchard is only a few feet higher. The mean annual temperature for the twenty-three years recorded is 72° F., and the average annual rainfall is 6.88 inches.

[a] See "Dry-land Olive Culture in Northern Africa," Bulletin 125, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1908.

TABLE I.—*Average rainfall by months and annual average for Casa Grande, Phoenix, Maricopa, and Mesa, Ariz., for the years from 1897 to 1908, inclusive.*[a]

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Casa Grande	[b]1.04	0.86	[b]0.36	0.25	0.03	[b]0.19	[b]0.97	1.03	[b]0.37	[b]0.13	0.88	0.78	[b]6.88
Phoenix	1.10	.90	.51	.51	.05	.11	1.03	.98	.98	.32	.89	.72	8.11
Maricopa	.78	.72	.38	.33	.04	.16	.91	.83	.52	.25	.72	.78	6.41
Mesa	1.11	1.02	.80	.49	.08	.12	.83	1.31	.59	.35	.861	.01	8.60
Average	1.01	0.87	0.51	0.39	0.05	0.14	0.93	1.04	0.62	0.26	0.84	0.82	7.52

[a] The figures of this table were kindly furnished by Mr. L. N. Jesunofsky, section director, Weather Bureau, Phoenix, Ariz.

[b] These means were obtained by substituting the mean of the month specified in places where the record was wanting.

Figure 2 shows graphically the average rainfall by months for Casa Grande, Ariz., and adjacent stations, from 1897 to 1908, inclusive. The two periods of greater rainfall each year, one culminating in

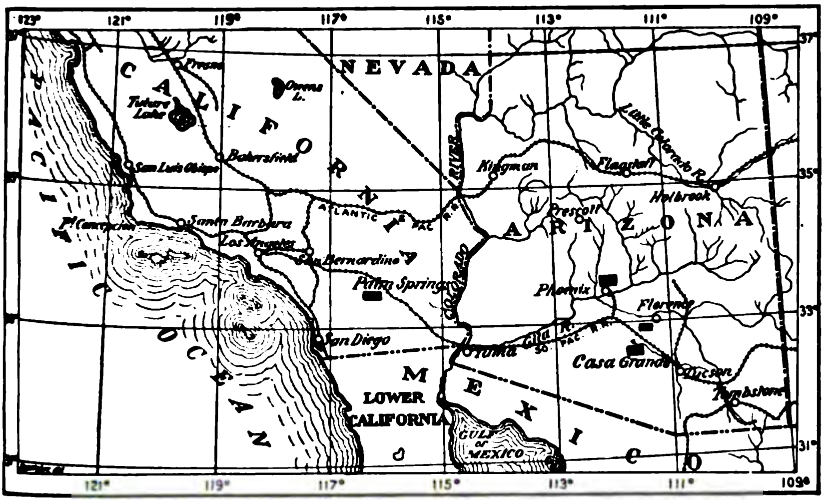

FIG. 1.—Map showing the points in Arizona and southern California where dry-land olive growth was studied.

August and one in November, with May and June nearly rainless, are characteristic of the region.

The range of temperature during the year is from a minimum of 25° or 28° F., with occasional years as low as 17°, to a maximum of 117° to 122° F. The mean relative humidity recorded for Phoenix in Table II and graphically illustrated in figure 3 will not be far from correct for the Casa Grande region.

TABLE II.—*Mean monthly and mean annual relative humidity of Phoenix, Ariz., for the years 1905, 1906, and 1907.*

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
1905	61	71	67	58	35	25	29	42	41	40	65	59	49
1906	50	60	48	40	31	20	34	47	30	31	45	65	42
1907	66	58	51	30	28	24	36	44	36	55	55	42	44

The country around Casa Grande is a wide plain, through the level of which the mountains appear to be thrust up, so abruptly do the scattering groups and single low peaks break the surface. These mountains are largely composed of a soft, rapidly disintegrating granite, with much feldspar in its composition, and their decay determines the character of the soil, which is coarse and gravelly around the mountain base, sandy with more of clay a little farther away, and of a stiff clay nature mingled with bars of sand and gravel along the drainage courses, scarcely as yet marked as stream channels, which serve to carry away the run-off from the occasional torrential rains so characteristic of the region.

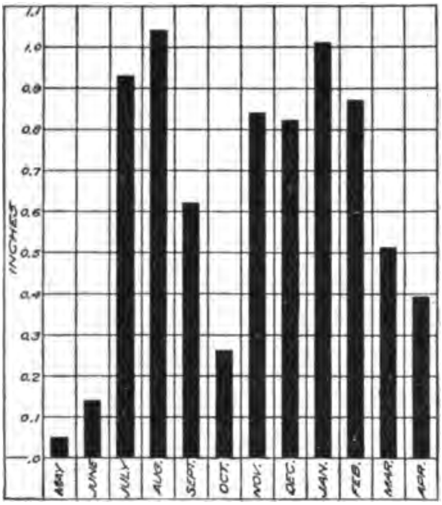

Fig. 2.—Diagram showing the mean monthly rainfall at Casa Grande, Maricopa, Phoenix, and Mesa, Ariz., as presented in Table I.

The most important of these water courses, sometimes dignified on the maps by being called the Santa Cruz River, is locally given the more appropriate name "Santa Cruz Wash." While along its upper course, from the Mexican boundary down to Tucson, there is a pretty well-marked channel and a more or less continuous flow of water, in the neighborhood of Casa Grande a slightly cut channel, a broad, well-marked flood area, and a still broader belt of mesquite growth mark the course of the so-called river.

Fig. 3.—Diagram showing the mean monthly relative humidity at Phoenix, Ariz., as presented in Table II.

The popular idea that there is a strong underflow of water the entire length of this valley is given support by the heavy belt of mesquite which occurs with more or less regularity along the course. This tree is well known throughout the desert regions of the Southwest as possessing a remarkable root system, able to penetrate to water-bearing strata at depths of 30 to 50 feet. The further fact that the railroad wells along the line of the Southern Pacific Company, particularly those at Maricopa and Casa Grande, 2 or 3 miles away from the main channel, afford

an abundant flow of water from deep borings, in which the water rises to within 40 to 50 feet of the surface, seems to confirm the impression.

The ranch of which the olive orchard forms a part lies fully 3 miles south of the main Santa Cruz channel, with a gentle slope toward it. A heavy mesquite growth had first to be removed as a preparation for planting, and much growth of the same nature is still to be found adjacent, indicating the presence of a water supply at a depth of 30 to 50 feet. The soil contains a large percentage of coarse granitic sand, but with enough clay to give it considerable body and cause it to bake when dry. (See Tables IV and V.)

THE BOGART-DEGOLIA OLIVE GROVE.

According to the best testimony available, the Bogart-Degolia ranch was planted in 1893. It was at the time of the highest prosperity of the so-called Florence canal, which took water from the Gila River near the town of Florence. About 20 acres of the ranch were set to Muscat and Thompson seedless grapes, figs, apricots, prunes, and olives, there being perhaps 5 acres of olives. The supply of water, while never abundant, was adequate for several years, and the enterprise gave every promise of success.

Owing to the partial failure of the water for the past seven or eight years, the trees have had no water save the rainfall and a little local run-off that the otherwise dry ditches carried to the orchard.

We have no record of the exact order in which the trees began to perish. When examined in March, 1907, all the trees planted were dead except the olives, a few Arizona ash (*Fraxinus velutina*) which had been set along the main ditch where they could profit by the run-off which it could collect, and a few fig trees which still sent feeble sprouts from the base. Appearances would indicate, however, that the apricots and prunes were the first to succumb, followed by the figs.

After the place was deserted, cattle and horses dependent on the scanty desert herbage broke into the inclosure and attacked the olive trees, browsing off all of the tender growth within reach. This fact in itself bears testimony to the scantiness of forage on this plain, for of all the forms of vegetation brought forward as forage plants the olive has not so far been considered in the United States.[a] Many of these trees were browsed and broken till mere prongs and stubs, 3 or 4 feet high, were all that was left of them. None of the trees seem to have been pruned from the first, and the greater number of them had formed several divergent stems from the ground. It was

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[a] Mr. Thomas H. Kearney states that during dry years in Algeria branches cut from olive trees are a regular forage supply. See Bulletin 80, Bureau of Plant Industry, U. S. Dept. of Agriculture, p. 80.

usually where the outer stems had formed a sufficient barrier against the stock that the central ones had attained an adequate growth to enable them to resist attack. Many of these have reached a height of 12 to 15 feet, and a few exceptionally strong specimens are 18 to 20 feet high. (See Pl. I, fig. 1.)

The foliage is a dark, luxuriant green, and vigorous new growth is being made, even on those trees that have been most severely cropped back by cattle. The whole plantation is a notable landmark on the desert plain and can be seen for a long distance. In fact, uncultivated and abandoned to struggle for itself, the olive has made a winning fight in fair competition with the mesquite of the surrounding desert, even though it has lacked the thorny defense against grazing animals which nature has supplied to the desert tree.

The uniform distance in setting out this entire plantation was in squares 24 feet apart. This would prove to be rather too close planting even in an orchard having an abundant supply of water, but where the supply is as scant as this plain affords experience has shown that this spacing, which provides for 75 trees to the acre, is much too close. The luxuriant growth of a portion of these trees was doubtless made possible by the weakened competition of those closely cropped by stock. The olive tree has the ability to produce a system of shallow roots, fully occupying the ground for a wide radius around each tree. But a few years are needed for a tree to completely take possession of the soil over a radius of 12 feet, after which the struggle must begin with neighboring trees for the available moisture.

A detailed study of the roots of a typical tree was made—a tree with a trunk diameter of only 5 inches, enlarged just below the surface of the ground into a burl 12 inches in diameter and 14 inches in depth, from which radiated 12 roots from a half inch to 2 inches in diameter. Some of these roots had a length of 12 to 14 feet. So numerous were the branches and small feeding rootlets originating from these roots that the soil from a depth of 2 or 3 inches to more than a foot was filled with them.

The description of "Olive root systems" in this bulletin will afford details applicable to all of these plantations.

At the remote areas penetrated by branches from the large roots the ground was contested by feeding roots from the adjacent trees, so that it was hardly possible to turn up a shovelful of earth in the orchard without finding evidence of this reaching out for moisture. Yet there was no taproot and no penetrating to great depths for water, as is so characteristic of the mesquite, which had been the natural occupant of this land. It was a most complete and perfect system for appropriating the moisture in the first 15 or 18 inches of the soil, just that which would be penetrated by the normal rainfall.

The soil, greatly deficient in humus, contains clay enough to make it very hard when dry, and the tramping of grazing stock still further compacted the surface, preventing the ready absorbing of water when a rainfall came. Application of the now well-known principles of thorough cultivation and light furrowing across the slope to secure water storage and the retarding of evaporation by a dust mulch would have aided these trees greatly in utilizing the rain which fell.

DRY-LAND OLIVE GROVE NEAR FLORENCE, ARIZ.

Not far from the Casa Grande and Florence road, in the valley of the Gila River and about 5 miles southwest of Florence (see map, fig. 1), a ranch was developed and a plantation of olives and other fruits was made, probably at about the same time as that at Casa Grande. An area of about 8 acres was set in olives, the trees being arranged in squares 20 feet apart each way. This tract has been kept securely fenced, so that no damage from live stock has occurred. From the scant information that can be gathered these trees have received no irrigation for six years.

The soil is a much stiffer clay than that at Casa Grande. A well near the orchard, now caved in, shows no water for a depth of more than 40 feet. An inspection of this grove shows that while possibly 5 per cent of the original setting of trees failed to grow, but a very few died later. The average height of these trees is about 20 feet. A majority of them grow in the form of stools, sending out several minor stems from near the ground. Some single trunks from 8 to 12 inches in diameter were noted. The formation of a much enlarged burl at the surface of the ground was a very common feature.

A most significant fact was that the trees around the borders of the grove were much larger and of more vigorous and healthy growth than those where there was a perfect stand in the interior. While few of the interior trees are dying, the scantier and less healthy foliage and more slender growth of the branches all testify to the severity of the struggle for moisture which is taking place. (See Pl. II, fig. 2.)

No systematic study of the root development was made, but a number of holes dug in various parts of the grove showed that, as in the Casa Grande grove, the extent of roots was such as to occupy the entire area, fine rootlets being disclosed wherever the soil was turned. Even where missing trees gave a diagonal distance of more than 45 feet between those standing, the roots had extended so as to occupy this space.

A most significant fact concerning this planting is shown in Plate II, from photographs taken in March, 1909. A block of about 3 acres of apricots and almonds planted by the side of the olives is shown in Plate II, figure 1, on the left. The trees had made an

excellent growth, but with the failure of the water every one of them has died. On the right are seen the olive trees still making a good growth. A few pomegranate bushes and pepper trees planted in the dooryard adjacent to the olives, while nearly all living, have apparently suffered more seriously from drought than the olives.

DRY-LAND OLIVE TREES NEAR PHOENIX, ARIZ.[a]

A few miles northeast of Phoenix, Ariz., a tract of land was laid off into a sort of residence park under the name of "Las Palmas."[b] Numerous avenues and drives were planted with Canary Island palms, pepper trees, and other ornamentals, and at the same time a considerable number of olive trees was set out, a row along the south side of the southeast quarter being half a mile long. Owing to difficulties about the water supply, cultivation and care ceased over all but a small part of the tract, so that for the past six years no irrigation has been given the olives and peppers on the south side of the section and only a small amount to some of the palms.

The soil here, though gravelly, is much richer in clay and fine silt than that of the Casa Grande tract. This portion of section 22 has for several years been heavily pastured by horses, cattle, and sheep, the trampling of this stock being sufficient to render the ground around the row of olives smooth and compact, so that much of the rainfall would be turned off instead of being caught and allowed to percolate to the roots. A much better supply of forage seems to have prevented the stock in this pasture from browsing the olives as severely as was done at Casa Grande, though apparently sheep have fed off the leaves and small twigs to a height of about 4 feet.

We find this to be a case of growth under decidedly adverse conditions, though not the most extreme. The row of olive trees along the south side of the section is uneven in growth, but many are 12 to 15 feet high, with trunks from 5 to 7 inches in diameter. Here, as in other droughty situations, the olive has a strong tendency to put out sprouts from near the base, thus protecting the trunk from the heat of the sun. This universal habit of olive trees in dry localities, even those that have been headed high enough to expose the trunk, points clearly to the desirability of a method of pruning which will provide a low, spreading head, thoroughly protecting the trunk and main branches.

That several of the trees in this south row should have fruited in 1907 in the face of such privation and neglect, though producing only a light crop, is strong evidence of the hardiness and drought resistance of the olive.

[a] See map, figure 1. [b] Comprising section 22, in township 2 north, range 3 east.

In the northern portion of the ranch olive trees which had received a little irrigation and less trampling and hardening of the ground produced fair crops of fruit, thus demonstrating that a small difference in conditions may be sufficient to decide between a mere holding on to life and a fair commercial success. The climatic conditions indicated in Table I for Phoenix will be a close approximation to those prevailing at this place. Plate I, figure 2, shows a characteristic tree of the south row in fruit.

THE POPE OLIVE PLANTATION, NEAR PALM SPRINGS, CAL.

DESCRIPTION.

In traveling over the Southern Pacific Railway from Los Angeles to the east, one leaves the orange groves of Colton and Redlands to ascend into a cooler region, an altitude of nearly 3,000 feet being reached in the San Gorgonio Pass. Here, around Beaumont and Banning, are flourishing orchards of prunes, peaches, and apricots, watered from the perpetual snows of the San Bernardino Range, and extensive barley fields moistened by the winter rains. A descent of 2,000 feet in 30 miles to Palm Springs station then brings one seemingly into another country. A sparse growth of desert shrubs and herbs in torrent-washed gravel and among bowlders replaces the orchards and harvest fields, and instead of the refreshing breezes from the snow-capped peaks there is much of the time a sand-laden gale blowing so steadily down the valley that all the desert shrubs lie prostrate and the drift of sand to the leeward of each makes it seem to be marking a nameless grave. Just ahead lies a low range of hills, their original rock formation barely suggested beneath the mantle of sand that centuries of winds have heaped upon them. No landscape could be in more striking contrast with that left behind at Colton and Beaumont.

Taking the trail to the southward from Palm Springs station for a few miles carries one out of the sweep of the winds to a sheltered section containing the picturesque little village of Palm Springs at the site of the old Agua Caliente. (See map, fig. 1.) The Mission Indian village lies on the east side of "Indian avenue" and a little group of homes of the white settlers on the west, all nestling under the shelter of the towering San Jacinto Mountain, whose two peaks, San Jacinto and Cornell, are among the highest in southern California. From a jagged rent in the eastern base of the mountain issues an ice-cold stream of water, a brawling torrent when the mountain showers are heavy or the snows are melting rapidly, but sinking to a tiny rivulet at the end of the long desert summer, barely sustaining life in the little oasis dependent upon it. In fact, during

a series of extremely dry years it has happened that the flow of 9 or 10 miner's inches, or about 120 gallons, per minute from the hot spring pool has been all there was to sustain plant or animal life for months at a time.

A little way out on the desert one notices rows of pepper trees (*Schinus molle*), their rich, dark green in sharp contrast with the desert herbs and shrubs, while a nearer approach shows, perhaps, a half-dismantled house and a broken fence inclosing a small field. Gaunt rows of cottonwood trees, a few still keeping up the struggle, the greater part standing stiff and white, seem ghostlike sentinels keeping watch along the line of a ditch that has long since ceased to convey the life-giving water. Acres of grapevine stumps, blocks of dead apricot trees, skeleton branches of bleaching fig trees, a few green sprouts struggling from their bases—all give eloquent testimony to the energy and capital invested in the Palmdale settlement in 1889, when the granite-lined canal brought a supply of water from the Whitewater River across 7 miles of blowing sand to irrigate this sheltered spot at the foot of the San Jacinto Range.[a]

In striking contrast to the impression of desolation offered by the majority of these abandoned fields is that of a tract lying a mile northeast of Palm Springs, Cal.,[b] where, if one ascends to a little elevation above the plain, the check rows in dark, rich green of an olive plantation of 26 acres shows in striking contrast to the brownish green of the creosote bush (*Covillea tridenta*), which forms the natural growth. Here in 1891 was set an olive grove of approximately 3,000 trees, together with some 6 or 7 acres of figs. (See Pl. III, fig. 1.)

CLIMATE OF PALM SPRINGS.

Palm Springs has the typical desert climate, modified somewhat by its proximity to the San Jacinto Range, which cuts off the fierce sweep of the winds which come down through the San Gorgonio Pass and spread out over the country above the Salton Sea. The summer's heat is intense and prolonged, maximum temperatures of 100° F. and over being reached every month from May to September, inclusive, and occasionally even in April and October. The absolute yearly maximum for the ten years from 1897 to 1906, inclusive, ranges from 113° to 122° F., only 1904 failing to reach 116° F. The lowest recorded winter temperature is 28°, but more often 32° F. is the record, and sometimes winters pass with scarcely a trace of frost. Although within 12 miles of the snow-capped San Jacinto peaks, the mean

[a] Since the studies herein described were made, much of the canal stock and a considerable acreage of land have been acquired by persons who have repaired the canal and begun again the appropriation of water from the Whitewater River.

[b] A portion of section 11, in township 4 south, range 4 east.

annual precipitation is a scant 3½ inches, with a total of only 0.70 inch for 1903 and a maximum of 9.36 inches for 1905. (See Table III.)

Scant as this rainfall is it nearly all occurs in the six months from October to March, inclusive. During the six summer months when a temperature of 100° F. is reached almost daily there is scarcely a trace of rain. (See fig. 4.) That any vegetation should be able to pass through this terrible period of heat and drought seems beyond belief to one accustomed to the behavior of plant growths of the regions having abundant rainfall; yet many species of shrubs and three species of trees are native in these hot sands.

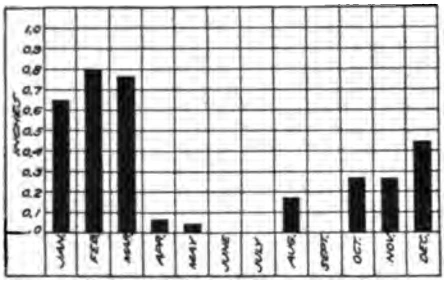

FIG. 4.—Diagram showing the mean monthly rainfall at Palm Springs station, Cal., as presented in Table III.

That the olive, whose beautiful groves are typical of the most favored portions of France and Italy, should be able to survive and even successfully compete with these desert shrubs in their own habitat, when planted among them and then abandoned, gives us a new insight into the real character of this tree that makes it worthy of careful study.

TABLE III.—*Maximum and minimum temperatures and precipitation at Palm Springs station, four miles north of the Pope olive plantation, California, elevation 584 feet, for the years 1897 to 1907, inclusive.*

MAXIMUM TEMPERATURE (DEGREES FAHRENHEIT).

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1897	68	74	83	103	108	111	120	118	104	97	89	78	120
1898	73	88	95	108	102	110	116	115	112	102	92	78	116
1899	82	84	84	102	92	116	116	114	113	96	90	86	116
1900	81	86	97	94	106	111	118	110	107	104	90	78	118
1901	78	98	96	95	98	118	111	114	106	98	90	82	118
1902	98	105	105	98	101	121	116	106	112	95	85	75	121
1903	70	72	85	97	111	112	117	116	112	98	88	81	117
1904	78	86	92	106	103	112	113	111	107	102	96	81	113
1905	72	70	81	78	110	110	122	115	110	98	82	74	122
1906	70	......	88	101	102	112	116	116	106	104	94	75	116
1907	74	84	91	100	95	115	118	......	102	100	88	78	....

MINIMUM TEMPERATURE (DEGREES FAHRENHEIT).

1897	38	32	37	40	39	65	77	81	68	55	42	30	30
1898	36	48	42	54	58	70	78	78	64	62	42	32	32
1899	30	28	46	56	60	66	85	70	70	50	50	32	28
1900	34	38	50	42	52	66	69	70	64	54	48	44	34
1901	30	44	50	58	64	61	75	80	65	65	47	30	30
1902	32	30	42	50	62	59	66	68	60	60	35	40	30
1903	40	32	46	50	54	60	65	68	58	58	50	34	32
1904	32	39	49	53	53	69	75	79	61	62	56	48	32
1905	45	28	50	46	50	60	75	80	70	60	40	30	28
1906	33	......	42	50	58	62	84	70	62	47	32	40	....
1907	30	46	42	55	52	70	72	......	60	60	46	35	30

TABLE III.—*Maximum and minimum temperatures and precipitation at Palm Springs station*—Continued.

PRECIPITATION (INCHES).

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1897	0	0	0	0	0	0	0	0	0	0	0	1.09	1.09
1898	......	0	0.60	0	T.	0	0	0	0	0	0	.70	....
1899	1.21	0.12	0	0	0	0	0	0.62	T.	0	0.50	2.86	5.31
1900	.80	0	0	0	0	0	T.	0	0	1.29	T.	0	2.09
1901	T.	3.50	0	0	0	0	0	0	0	0	0	0	3.50
1902	.50	0	.50	0.50	0	0	0	0	0	0	.70	.70	2.90
1903	0	0	.70	0	0	0	0	0	0	0	0	0	.70
1904	T.	T.	......	0	0	0	0	1.00	0	.10	T.	0	....
1905	2.16	3.95	1.66	T.	0.48	0	0	0	0	0	1.11	0	9.36
1906	.46	......	3.05	.20	0	0	0	.10	0.05	0	.70	.56	....
1907	1.27	.47	1.27	.15	0	0	0	......	0	1.64	0	T.	....

T.=trace.

SOIL AT PALM SPRINGS.

The soil of the olive orchard is typical of this district. The rock formation is coarse sandstone and granite. The southern face of the mountains is broken by canyons of various widths and depths, originating as rents and fissures in the uplifted rock, but enlarged by the erosion of the mountain torrents, which were apparently during glacial times of vastly greater volume than at present. The result has been an enormous talus of water-worn bowlders from each of the main canyons extending out into the basin to an unknown distance and depth and spreading laterally along the mountain base. Over this is a varying depth of coarse sandy and gravelly soil, in places mixed with a considerable quantity of finer material from the sorting action of wind and water. Several square miles in the Palm Springs and Palmdale region have thus a fair quality of sandy soil, which is lacking in sufficient clay or fine binding material and because of the scanty rainfall and sparse vegetation is low in organic matter. Judging from the quantity of feldspar in the original granitic rock, there is doubtless a good deal of available potash in this soil.

On the particular 40 acres in the olive orchard there is rather less of the finer material in the soil than in that of the Indian reservation lands adjoining on the south. Layers of coarse gravel and cobblestones are often encountered at depths of 3 to 4 feet. The longest winter rains sink so quickly into the soil that there is no trace of stickiness or mud on the following day.

TABLE IV.—*Mechanical analyses of soils from olive orchards at Casa Grande, Ariz., and Palm Springs, Cal., made by the Bureau of Soils, U. S. Department of Agriculture, from samples collected by Mr. S. C. Mason.*

Locality.	Depth taken.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
	Inches.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Casa Grande, Ariz	0 to 6	4.0	15.1	10.4	25.0	11.1	27.1	8.0
Do	6 to 12	3.7	13.5	9.1	26.0	10.0	32.3	5.0
Do	12 to 18	4.4	14.0	9.4	25.0	9.1	32.1	6.6
Palm Springs, Cal	0 to 6	4.0	15.2	42.0	17.7	13.2	7.2	.8
Do	6 to 12	4.0	15.0	15.4	43.4	13.1	8.0	.9
Do	12 to 18	3.4	14.1	14.0	40.2	14.9	11.3	1.6

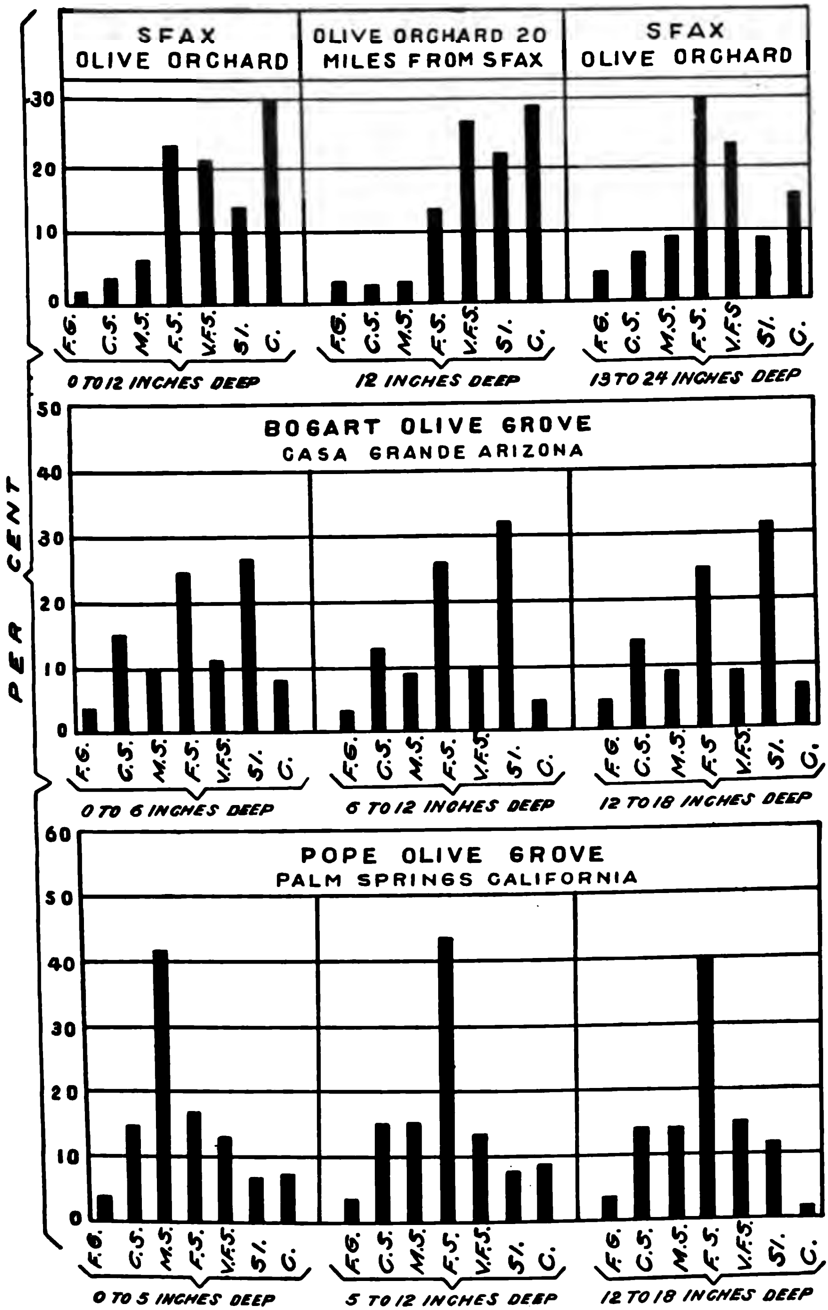

FIG. 5.—Diagram showing the relative percentages of fine gravel, coarse sand, medium sand, fine sand, very fine sand, silt, and clay in dry-land olive plantations in northern Africa (Sfax) and in Arizona and southern California.

TABLE V.—*Analyses for potash, phosphoric acid, calcium, and organic matter in soils from olive orchards at Casa Grande, Ariz., and Palm Springs, Cal., made by the Bureau of Soils, U. S. Department of Agriculture, from samples collected by Mr. S. C. Mason.*

Locality.	Depth taken.	CaO.	K_2O.	P_2O_5.	Organic matter.
	Inches.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Casa Grande, Ariz	0 to 6	1.18	0.98	0.03	0.15
Do	6 to 12	.53	1.00	.22	.46
Do	12 to 18	1.85	1.00	.32	.66
Palm Springs, Cal	0 to 6	1.58	.81	.52	.19
Do	6 to 12	1.58	1.02	.38	.12
Do	12 to 18	1.75	.80	.41	.17

Figure 5 shows in a graphic manner the results of a mechanical analysis of this soil by the Bureau of Soils, as presented in Table IV. This is placed for comparison below a diagram showing the results of a similar analysis of the soil from the Casa Grande olive grove and one from the olive orchards of Sfax.[a] The small quantity of clay and silt and the large proportion of medium and fine sand distinguish

[a] See "Dry-land Olive Culture in Northern Africa," by Thomas H. Kearney, Bulletin 125, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1908, pp. 18–19, as follows:

Mechanical analyses of soil samples from the olive orchards of Sfax.

Locality.	Depth taken.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
	Inches.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Olive orchard, Sfax	0 to 12	0.2	4.3	7.1	24.1	20.9	14.1	30.0
Do	13 to 24	.4	7.7	9.7	33.9	24.0	9.1	16.0
Do	25 to 36	.5	7.9	10.3	34.3	24.6	7.1	15.7
Do	0 to 12	.2	4.6	6.8	26.4	22.5	13.4	26.2
Olive orchard, 20 miles north of Sfax	(a)	.3	2.7	3.3	14.9	27.0	22.9	29.3

[a] Adhering to olive truncheons, probably about 12 inches.

Chemical analyses of a large number of samples of the Sfax olive soils by the chemist of the Tunisian government show them to be very rich in lime (calcium carbonate), of which there is an average of from 5 to 10 per cent. The potash content is also good, the average being 0.1 to 0.2 per cent. On the other hand, they are rather poor in nitrogen (0.03 to 0.05 per cent) and in phosphoric acid (0.04 to 0.05 per cent). According to Trabut, a high lime content is a very favorable factor in growing olives for oil production, as olives produced in limestone regions are richer in oil and the oil is of better quality then where the soils are deficient in this component. It should be noted that while the nitrogen and phosphoric acid content of the Sfax soils would be considered low for most crops, the high yields and good quality of the oil produced at Sfax are sufficient evidence that the supply of these two elements of plant food must be amply sufficient for the requirements of the olive. This can perhaps be explained by the fact that the roots of this tree occupy so great an area of soil (one-seventh to one-tenth acre) that, while the percentage of these elements to weight of soil is everywhere low, the total amount available to the roots is actually rather high.

this Palm Springs soil in a very marked way from that of the Casa Grande. Both are in striking contrast with samples from the dry-land olive district of Sfax, in northern Africa, described in Mr. Kearney's bulletin previously referred to. The much higher percentage of clay in the Sfax samples gives a very distinct character to that soil, which as it exists in nature impresses one as sandy, owing doubtless to the clay and silt particles being cemented together.

In chemical composition these soils (Table V[a]) show a striking similarity in the lime content, having only one-eighth to one-fourth as much of that element as is found at Sfax.

In the amount of potash the Casa Grande and Palm Springs samples are also very much alike, being five to ten times richer than the Sfax samples. In the amount of phosphoric acid it is interesting to note that the Palm Springs soil, though seemingly a desert sand, contains more than twice as much of this important element as is found in the Casa Grande samples. In the potash and phosphoric acid contents either of these samples compares favorably with average agricultural soils; for instance, with the soils of the famous Michigan peach belt,[b] while in phosphoric acid the Palm Springs samples, averaging 0.436 per cent for the entire 18 inches in depth, are ahead of all but the very richest farm lands of the eastern United States. This richness of desert soils in phosphoric acid and potash is especially advantageous to olive culture, as investigations by the California Agricultural Experiment Station have shown that the olive makes much higher demands upon the soil for these elements than do grapes, plums, apricots, or oranges.[c]

HISTORY OF THE GROVE.

As nearly as can be gathered the greater part of the Pope olive orchard was set in 1890 and 1891. There was at that time an adequate supply of water available from the Whitewater ditch, which was conveyed to each block of land by box conduits. Along these conduits and across the north side of the blocks rows of cottonwood trees were set 20 feet apart. Their influence on the olive plantation will be referred to later.

The olive trees were planted 21 feet apart on the hexagonal system, giving 116 trees to the acre. For the first seven or eight years there was a fair supply of water. No Bermuda grass or other serious weed gained a foothold and the work of irrigating the trees was the chief

[a] From analyses by Mr. Joseph G. Smith, of the Bureau of Soils, U. S. Dept. of Agriculture.

[b] See Roberts, I. P., "The Fertility of the Land."

[c] Report of the Director of the California Agricultural Experiment Station, 1894–95, p. 124.

labor. It can not be learned that during that time any fruit was produced. A resident of Palm Springs who came there in 1896 recalls that they were "expecting the trees to come into bearing the next year." About this time difficulties with the water supply began, and as nearly as can be ascertained no irrigation at all has been given the orchard since 1900.

PRESENT CONDITION OF THE GROVE.

The first fact with which one is impressed on seeing this plantation is the small size of the trees considering their age. Some trees are scarcely 4 feet high, and very few more than 7 or 8 feet. Taking two average rows, the range in height was found to be from 41 inches to 98 inches, the average for 50 trees being 63.5 inches. The highest tree in the 20-acre block was found to be 9 feet, while only 10 trees could be found measuring 8 feet and upward. (See Pl. III, fig. 2.)

It is to be noticed that on these trees the branches are retained clear to the ground and that the breadth of the top exceeds the height in almost every case, so that in the 50 trees examined only one was found in which the height was greater than the breadth of top. The average breadth for the two rows is 79.5 inches as against 63.5 inches of height. These tops, too, are much branched and very compact. In nearly every case the trunk is concealed. A leafy canopy protects the trunk and main branches from the dry air and fierce heat of the desert sun.

In doing battle for their lives in the desert they have shown their ability to adapt themselves to desert methods of defense. The mesquite and paloverde,[a] the largest native trees, may attain a spread of top of 40 or 60 feet with a height of only 20 or 30 feet. The desert willow (Chilopsis) and the *Dalea spinosa*, two species somewhat less resistant to drought and heat, attain a treelike size by throwing out a defense of sprouts and low branches, or, failing in this, they are apt to show scars of severe sun scalding.

The so-called "wild apricot" (*Prunus fremontii*), venturing out a little way along the bowlder talus from the canyon's mouth, has a top so densely branched, angled, and interlocked as to well merit the name Emplectocladus, signifying interlocked branches, which now applies to the whole subgenus to which it belongs.

Similar proportions of height to spread of top will be found in nearly all of the characteristic desert shrubs, the effort seeming to be to throw as much shade and insulation as possible around the trunk and main branches.

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[a] *Cercidium torreyanum* (Wats.) Sargent.

This purpose is accomplished most effectively and in the most characteristic way of all by that typical desert tree, the majestic palm (*Washingtonia filifera*), whose dying lower leaves suspended by their long petioles form a dense thatch, completely insulating the tall, columnar, branchless trunk against both the direct and reflected heat of the sun and the drying winds. Where some vandal hand does not apply a torch, this splendid protection is retained for many years, perhaps for life.

It is probable that in the case of the olive, as well as of many native desert plants, this low, spreading canopy of top serves another purpose. Of the total precipitation for the year in these regions a considerable proportion is in the form of small showers, so that the monthly record will often be indicated by such fractions of an inch as 0.12, 0.09, 0.32, 0.06, trace, etc., these usually representing a single precipitation. Such an amount falling upon the parched soil in the open is so soon evaporated as to afford little aid to the thirsty plant. Arrested by the leaves or fine branches and carried to the ground at the base of the stem, it is so shaded and conserved as to be allowed to sink into the surface soil, where a system of short, finely branched superficial roots is ready to appropriate it. In Plate IV, figure 2, such rootlets of the olive tree are shown in natural size.

Inspection of the whole 26 acres of the plantation shows that several varieties were set, just what they were being difficult to decide with accuracy, no plat or planting list so far having been discovered. The block in which the most trees are alive and in the best condition, though not making the largest growth, has the dense, compact habit and broad top most completely developed, and here any exposure of trunk or main branches to the sun is hard to find. These trees are noticeable for the complete absence of any sun scald on the bark.

The northern seventeen rows of this block are ranker in growth and more coarsely branched, and while the leaves are larger the whole canopy is much thinner. Of this variety, probably Manzanillo, a quarter of the trees are dead and others have suffered severe sun scald. In other cases a portion of the top has died back, to be followed by a vigorous sprouting from below. Of a block of four rows adjacent to this, not 10 per cent of the trees are alive, but these appear to be of a variety little adapted to these conditions.

The cottonwoods already referred to, bounding the 20-acre block on the west and north sides, are all dead, but so also are the olive trees next to them. Of the Manzanillo olives, the two rows on the north and next to the cottonwoods are two-thirds dead, while the third row is in bad condition. Of the trees on the west ends of the rows next to the cottonwoods in the larger block not so large a propor-

tion is dead, but those alive are small and in bad condition. Figu 6 shows very distinctly the effect of the cottonwood growth on tl olives. The struggle has been so intense for a bare survival on tl part of the whole plantation that the competition with a powerf feeder like the cottonwood has proved fatal, though the cottonwoo probably survived the olives but a few years.

Crossing the conduit to the next 20-acre block, only half of whic was set, are two small blocks of olives, 6 acres in all, with 4 acres figs between them. Here the contrast between the green of the oliv on either side and the figs, which are dead save a few strugglir sprouts, illustrates in a most marked way the comparative drougl resistance of the two. Indeed, of exotic trees on this ranch only tl

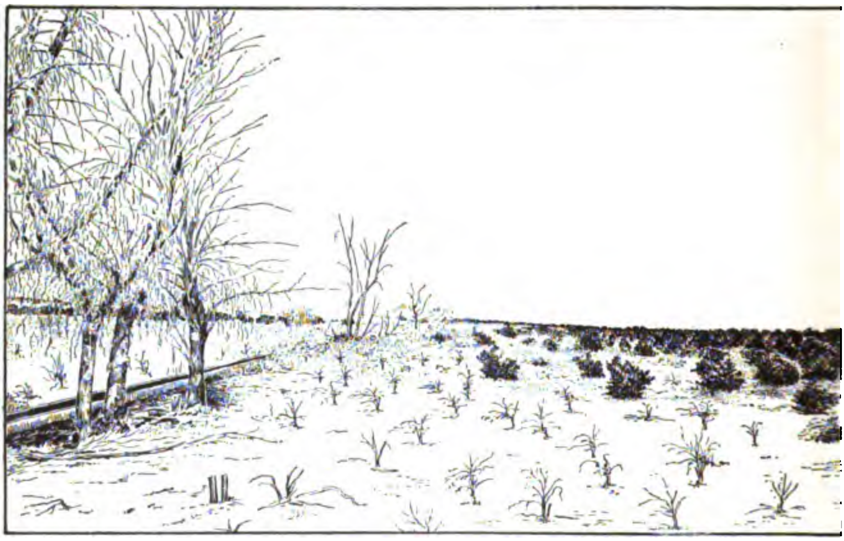

Fig. 6.—Olive trees which have died through competition with a row of cottonwood trees on the Pop olive plantation, near Palm Springs, Cal. (From a photograph.)

pepper trees bordering one field show an ability to endure thes extreme conditions equal to that of the olive.[a]

While trees of this slow growth and evergreen nature are conse quently slow in forming what the foresters call dominant and sup pressed classes, a close inspection of this grove shows such a work t be in progress, not as is generally the case in a forest by the proces of dominant trees overtopping and shading the weaker ones, but by means of dominating root systems by which once a tree has gained

[a] A visit was made to this plantation on April 13, 1908, at which time about 20 per cent of the trees of the more resistant variety of olives was in blossom, but at a late visit, June 11, not a single fruit could be found to have set. On the same date two olive trees in Dr. Wellwood Murray's irrigated garden in Palm Springs village were carrying fair crops of fruit.

the ascendancy in water appropriation it will sooner or later have three or four adjacent trees in the suppressed class. This suppression of the weak trees by the stronger rooted dominant ones begins as soon as the roots meet in the intermediate territory, which has happened in many instances in this grove and seems to account for the death of many of these trees and the weak condition of others. This affords conclusive proof that olive trees can not be grown successfully 21 feet apart under light rainfall without ample irrigation, and, what is more significant, that when given wide planting they are capable of extending their root systems and collecting their water supply from a very wide area.

OLIVE ROOT SYSTEMS ADAPTED TO UTILIZE LIMITED RAINFALL.

The remarkable endurance of drought displayed by the olive trees of which an account is given in this paper, but especially by those at Palm Springs, Cal., must be explained (1) by unusual ability to collect moisture from a soil supply normally deficient and (2) by an ability to conserve that moisture and perform their physiological work on a supply that would prove totally insufficient for ordinary trees. For the first we must look to the roots, and as these were uncovered and plotted it became evident that the deeply penetrating system possessed by the mesquite for bringing up water from a subterranean source was not possessed by the olive, nor would it have availed much, as on near-by land a well had been sunk to a depth of 80 feet, disclosing only dry cobblestone and gravel. No penetrating taproots were found, but usually each tree had a deeply-seated burl or swelling two or three times the diameter of the trunk above ground, from which radiated evenly in all directions a strong set of roots running off nearly horizontally. Plate IV, figure 1, shows the trunk, burl, and main roots of a tree which was selected for study from the most resistant variety of the Pope plantation.

This tree was barely 6 feet in height, with a top spread of 7 feet and a trunk diameter of 3¾ inches; yet we find a root system radiating to 10 and 11 feet in nearly all directions and having a total length of roots of one-eighth of an inch in diameter and upward of about 185 feet. The length of roots was at least double that of the twigs and branches of similar diameter, while the area occupied by the roots was nine times that of the spread of the branches.

The strongly gnarled burl was a foot in depth, and from this the roots issue at depths of 2 to 10 inches. With but a few exceptions they all break up into fine rootlets at depths of 5 to 8 inches, the greatest number being at 6 inches. In two cases small laterals penetrate to 18 inches in depth, and there was a curious case of branches from two separate roots going down at the same point—possibly an old burrow of some rodent affording a more mellow soil—to 36 and 42

inches, respectively, beyond which point they were not excavated and were still one-eighth of an inch in diameter.

The block of the Manzanillo variety at the north end of the 20 acres showed a different behavior from that of the main body of the grove. The wood growth averaged much ranker, but the branches were coarser and the tops more open to the sun. Far less adaptability to conditions is evident. Dead trees, trees with dead tops but with live sprouts from below, dead branches, and sun-scalded spots on exposed places are to be seen on every side. In this block the tree selected for study was 8 feet high, with 8 feet spread of top and a trunk 5 inches in diameter. A still stronger root system was found here, there being ten roots of from three-fourths of an inch to 1½ inches in diameter springing from the burl at the following depths below the surface: Two at 2 inches, one at 3 inches, one at 12 inches, three at 14 inches, two at 16 inches, and one at 18 inches. It being evidently impossible to keep track of all of these at one excavation the surface roots were excavated by themselves. These comprised three strong roots, issuing at 2 and 3 inches below the surface, and a circle of short fine roots, which the writer called the shade roots from the fact that they occupy the space immediately beneath the spread to the top.

Figure 7 shows these superficial roots represented in solid lines, while the deeper roots are shown by dotted lines, but it should be noticed that a number of the shallow roots figured came up to join this class from roots of deep origin. These shallow roots taken together may be regarded as a very important part of the equipment of the tree. Their rootlets reach to quite near the surface, so that they are prepared to gather moisture from a small rainfall. The shade roots appear to collect also the water which is arrested by the top and runs off to the ground from the trunk. It must be remembered that the medium in which these trees grow is so nearly pure sand as scarcely to be called a soil. There is a good deal of fine material in it, but it does not bake or pack, and cracks never occur. It is very doubtful whether any method of soil culture, dust mulch, or subsurface packing would be of value here. All that such treatment is expected to accomplish is already insured by the nature of this soil, and, furthermore, any cultivation would only destroy these delicate rootlets so nicely adapted to taking advantage of the lightest rainfall. Referring to the deeper roots in figure 8, we notice first the large area occupied by them as compared with the spread of the top. The roots of this tree over one-eighth of an inch in diameter have a total length, including the upper layer, of approximately 376 feet. The area of the root spread, as compared with the spread of the top, would be a little more than 7 to 1.

The depth of the course followed by these large roots of 12 to 18 inches is a very marked feature. Most interesting is the deep pene-

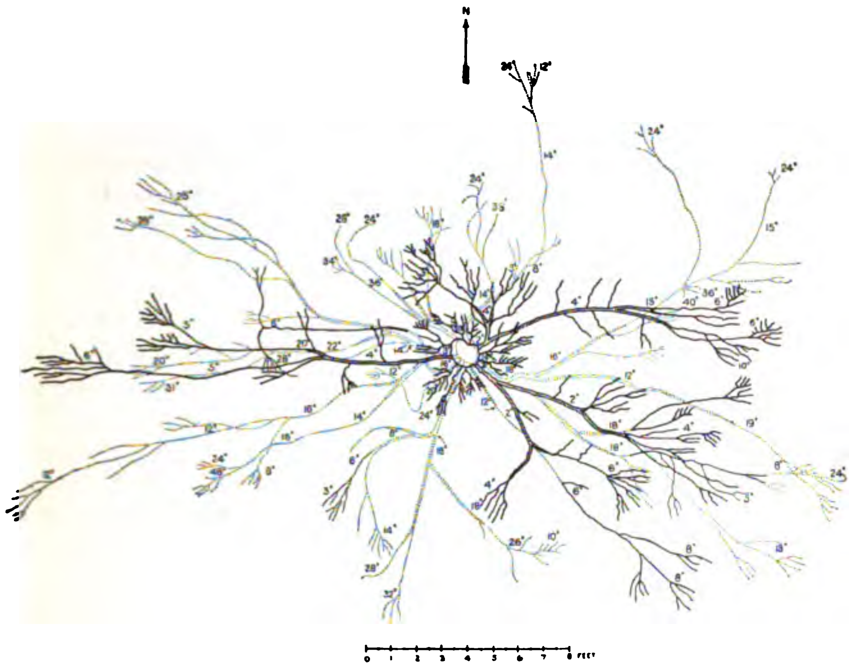

FIG. 7.—Diagram showing the distribution of superficial roots (solid lines) and deep roots (dotted lines) of a Manzanillo olive tree on the Pope olive plantation, near Palm Springs, Cal.

tration, almost vertically, of branches from many of these roots to depths of 2, 3, 4, and even 5 feet, where they were left, owing to the

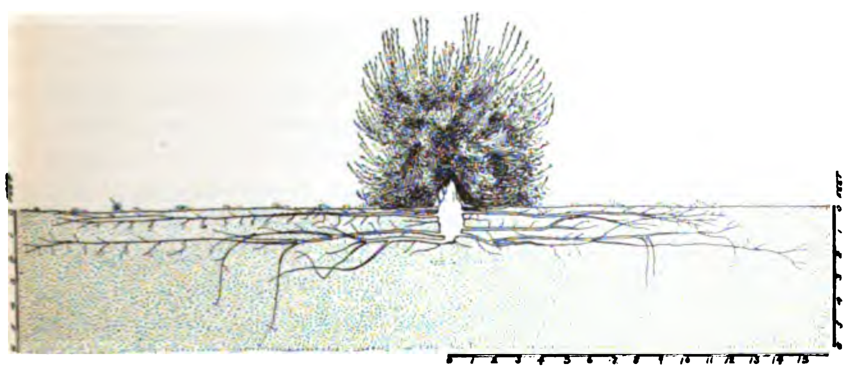

FIG. 8.—Diagram showing the root system of a typical dry-land olive tree on the Pope olive plantation, near Palm Springs, Cal., showing the position and distribution of the roots in the soil.

difficult nature of the digging. In most cases gravel and cobblestones of considerable size were encountered at these depths, and as

these were all old, hard roots it seems probable that they had gone down to these depths during the years when the orchard was still irrigated. The rootlets branching from these and all the deeper lying roots were much fewer than those nearer the surface.

A point previously referred to of special interest in this study is that of a number of deep-lying roots at points several feet from the tree sending off branches which rise suddenly to the level of 4 to 8 inches, along which levels they make a growth of several feet, sending off numerous branchlets and small feeding rootlets. These ascending laterals were found to show but three or four rings of annual growth while the main root (though it was impossible to count the rings accurately) was several years older. Evidently the upper growth had been made since irrigation ceased in an effort to reach the more favorable conditions for moisture and air at the upper level. In both trees studied, as well as in many others where small excavations were made, fine-feeding rootlets were found in considerable numbers at 2 to 24 inches in depth, but the zone of their greatest abundance was at 4 to 10 inches. Plate IV, figure 2, shows a section of a long root from a depth of 6 inches, with lateral branches and feeding rootlets, from a photograph of exactly natural size.

MOISTURE ECONOMY AIDED BY THE STRUCTURE OF THE OLIVE LEAF AND STEM.

In addition to the elaborate arrangement of olive roots for collecting the last particle of moisture possible from a sandy desert soil, there must still exist a remarkable economy in tissues and functions to enable a tree to survive, not to say to make growth, under such conditions.

It is to the leaves that we must look chiefly for this work. Their narrow form, reflexed margins, thickness, and tough leathery texture, as well as the densely hairy, almost felted under surface, all indicate that they are prepared to resist to the extreme the drying influence of the desert air. The minute anatomy of the leaf and stem of the olive has received considerable attention from botanists, but apparently no attempt has hitherto been made to ascertain to what extent different environments affect modifications of structure. That some light might be had on this most interesting point, material was procured by the writer of this bulletin from olive groves of California and Arizona, the samples being obtained from such widely diverse environments as the moist, fog-laden air and ample irrigation of Niles, near the San Francisco Bay, and the extreme of desert dryness and heat of Palm Springs, Cal. These were placed in the hands of Dr. Theodore Holm, whose study of them, illustrated in Plate V, figures 1 and 2, and five text cuts, is given in the Appendix to this bulletin.

SUCCESSFUL DRY-LAND OLIVE CULTURE IN CALIFORNIA.

In contrast with the mere endurance test of which the preceding examples are very instructive illustrations, there is in the so-called "inside" region of southern California, between the ocean and the mountains, an olive industry based on the local rainfall on lands above canal lines or lacking a sufficient water supply. Excellent examples of this type of olive culture may be found in the neighborhood of Beaumont, Riverside County; La Mirada, Orange County; Chatsworth and San Fernando, Los Angeles County; in Santa Barbara County; and also in the more northerly part of the State near Oroville.

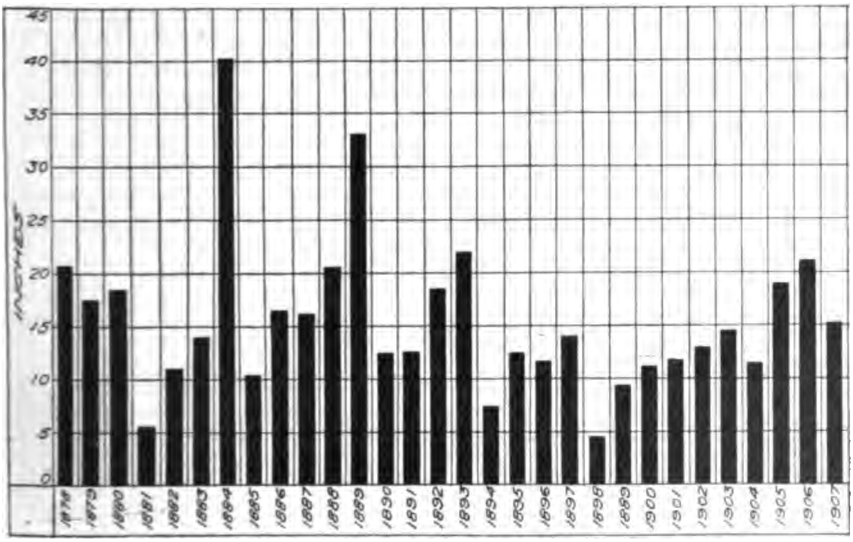

FIG. 9.—Diagram showing the annual rainfall at Los Angeles, Cal., as presented in Table VI.

While varying considerably in their climatic conditions they all agree in these general features: A minimum temperature never below 20° and seldom lower than 28° or 30° F.; a maximum summer temperature of 105° in cooler seasons to 114° F. in extremely hot years, but with a monthly mean temperature not below 48° in winter and seldom exceeding 80° F. in summer. From a study of Table VI, represented graphically in figure 9, we may see that the annual rainfall at Los Angeles has exceeded 12 inches during more than half of the years recorded, occasionally rising to 22 or 23 inches, or even higher, and only in rare years of drought falling as low as 7½ inches, with the minimum of 4.83 inches during the thirty years recorded.

TABLE VI.—*Annual rainfall at Los Angeles, Cal., 1878 to 1907, inclusive.*[a]

Year.	Inches.	Year.	Inches.
1878	20.86	1893	21.96
1879	17.41	1894	7.51
1880	18.65	1895	12.55
1881	5.53	1896	11.80
1882	10.74	1897	14.28
1883	14.14	1898	4.83
1884	40.29	1899	8.69
1885	10.53	1900	11.30
1886	16.72	1901	11.96
1887	16.02	1902	13.12
1888	20.82	1903	14.77
1889	33.26	1904	11.88
1890	12.69	1905	19.19
1891	12.84	1906	21.31
1892	18.72	1907	15.30

[a] For the data used on the climate of California, the writer is indebted to Mr. A. B. Wallaber, of the Climate and Crop Service of the United States Weather Bureau at Los Angeles, Cal.

TABLE VII.—*Mean relative humidity at Los Angeles, Cal.*[a]

Month.	5 a. m.	5 p. m.	Month.	5 a. m.	5 p. m.
January	67	64	August	87	63
February	73	63	September	82	63
March	80	65	October	78	68
April	82	63	November	64	65
May	87	65	December	61	64
June	87	61			
July	90	62	Year	78	64

[a] For the data used on the climate of California, the writer is indebted to Mr. A. B. Wallaber, of the Climate and Crop Service of the United States Weather Bureau at Los Angeles, Cal.

The rainfall of this region is enhanced by frequent coast fogs. The mean relative humidity from month to month is an important factor in all such cultural problems, but this is obtainable only for Los Angeles, with which point we may fairly compare Los Angeles County and Orange County. This, it will be seen from Table VII, ranges from 61 to 90 per cent for the 5 a. m. observation, and from 61 to 68 per cent for the 5 p. m. observation. This condition of atmospheric moisture would give orchards in these localities a great advantage, for instance, over the one studied at Palm Springs in the edge of the Colorado Desert, except that the trees suffer more from the attacks of parasites in the more humid climate.

One of the most extensive examples of olive culture without irrigation in this region is to be found on a large ranch in the southern part of Los Angeles County, near La Mirada, Cal. Here are 500 acres in olives, the oldest set sixteen years ago and others as recently as seven or eight years ago. The planting distance was only 20 feet, giving 108 trees to the acre. The olives occupy rolling hillside land for the most part, difficult of irrigation even if a water supply were at hand. The soil is as a rule a rather strong adobe, with some admixture of sand in parts of it. The nature of the hills nearest would indicate an abundance of lime in this soil, which is so important for olive production. Some degree of cultivation is given between the rows, but with

the older trees the spread of the branches prevents reaching all of the surface.

The original plan was to remove half of the trees as they began to crowd by cutting out every other row on the diagonal. The effect of this is to leave one-half, or 54 trees to the acre, in rows 20 feet apart, and trees 40 feet apart in the row alternating. This has been done with some blocks of the older trees and is a very evident gain. Where the original stand of the older trees still remains there is evidence of crowding and lack of thrift in many cases, and the writer is convinced that a stand of only 27 trees to the acre, or 40 by 40 feet, would be still better as the trees advance in age. The great vigor and productiveness of the trees along the draws and low places where any surplus of rain would flow give evidence that water famine had been felt by the small trees.

A notable feature of this orchard was the prevalence of the common black scale, a parasite found on olive trees all along the range of the ocean fogs unless vigorously combated, and not found to a harmful extent in the interior valleys of California or Arizona. How seriously this scale interferes with the functions of the tree is a matter upon which olive growers differ widely, but there is no difference of opinion as to the scale preventing the production of an olive of good pickling qualities.

Of the varieties planted, the Mission is the most prominent and satisfactory, though considerable blocks of the Nevadillo, the Pendulina, and the Columbella are also grown.

Plate VI, figure 1, shows a general view across a small valley in this orchard, and figure 2 a view among the rows of older trees thinned by removing alternate diagonal rows.

In comparison with this orchard stands the case of a ranch 2 or 3 miles away, the soil and location being practically the same. Here 400 or more acres of olives, probably differing little at the start, have for several years been in absolute neglect. Many of the trees were never properly headed up, being mere stools of several shoots from the ground. No evidence of cultivation could be seen, but grass, weeds, and small shrubs robbed the trees of the needed moisture. This, with the close planting, had reduced the problem to one of existence instead of profitable production. There was some fruit, and occasional trees enjoying some little advantage in space and moisture were bearing fair crops. These only helped to prove the fallacy of the idea that the olive is a tree that may be planted upon dry and barren soil, given absolute neglect, and yet produce profitable crops of fruit. Here in these contrasted orchards, with soil, rainfall, and temperature similar, the difference between pruning and culture on one hand and neglect on the other made the difference between a profitable industry with a fine product and a poor and scant crop not worth going over the ground to gather.

AREA OF POSSIBLE DRY-LAND OLIVE CULTURE IN THE UNITED STATES.

AREA LIMITED BY THE MINIMUM TEMPERATURE.

Of the factors defining the area of olive culture in the United States, that of minimum temperature is the most important.

It has been claimed by some authors [a] and by many olive growers that an actual minimum temperature of 14° or 15° F. will prove fatal to the olive tree. It is undoubtedly true, however, that the olive will endure considerably more cold than this if it is in a thoroughly dormant condition. This is especially true where the atmosphere is dry and where the low temperature persists for only a short time, possibly a few minutes at near daylight, as is so often the case in the southwestern sections.

As an illustration of these ideas, in 1899,[b] from February 11 to 13, a cold wave of unusual intensity swept over a great portion of the Southwest, temperatures of −6° to −23° F. being recorded in northern Texas, and as low as 8° F. in the southwest border.

At San Antonio two stations gave minimum records of 4° F. At Fort McIntosh, on the Rio Grande near Laredo, a minimum temperature of 5° F., probably for only a brief period, was recorded on the morning of February 12, and at Fort Ringgold, 90 miles down the river, a temperature of 7° F. was recorded on the morning of February 13.

An olive grove of an acre or more about 2 miles from Fort McIntosh suffered some killing back, though the trees were not seriously injured and may be seen to-day looking as vigorous as any in the olive-growing districts of California or Arizona.

At the dry-land experiment station of the Bureau of Plant Industry, near San Antonio, Tex., young olive trees of the Chemlali variety endured a minimum temperature during the winter of 1907–8 of 18° F., with but a slight killing back at the tips. Yet in 1909 these olive

[a] A temperature of 5° C. below zero (or 23° F.), followed by a sudden thaw operated by the sun's rays, is sufficient to kill it totally at the base. With a lower temperature not followed by sunny days the plant does not suffer as much, as it can stand a cold of 10° C. below zero (or 14° F.).—*Olive Culture, Italy, Annual Report of the State Board of Horticulture, California, 1890, p. 449.*

"A low temperature, say 14° F., is fatal to the tree."—*B. M. Lelong, Investigation Made by the State Board of Horticulture of California Olive Industry, Sacramento, 1900, p. 8.*

"The olive can grow in all regions where the minimum temperature does not fall below −7° or −8° C. and does not last more than eight days."—*Translation from Hidalgo Tablada.*

[b] Annual Summary, 1899, Texas Section, Climate, and Crop Service, Weather Bureau, U. S. Dept. of Agriculture.

trees and trees of several varieties planted in 1908 were with one exception killed to the ground under conditions where the minimum temperature reached was only 18° F. After mild weather during the latter part of December and the early part of January, with maximum temperatures of 76° and 77° on January 9 and 10 and 63° F. on the following day, a "norther" brought the temperature to 20° at 3 p. m. on January 11, with a minimum of 18° F. at night. On January 12 the minimum was 18° with a maximum of only 22°, and there was a minimum of 22° on the morning of January 13, the temperature thus being maintained about forty hours at from 10° to 14° below freezing. These trees were in a plat which in accordance with the general cultural policy of the farm had been kept under fine surface tillage, enabling the soil to store abundant moisture from the season's rains. This arrangement prevented the olive trees from entering the dormant condition necessary to their resisting the low temperatures, and the freezing sap burst the bark of most of them and killed all to the crown, from which they sprouted again freely.

At Boerne, 30 miles northwest of San Antonio and 700 feet higher in altitude, the temperatures registered were 1° lower each day of this cold spell than those at the San Antonio farm, yet the olive trees there sustained much less injury.

A region may have monthly mean temperatures and an annual mean sufficient to place it high in the scale when compared with well-known olive regions, yet where high winter means include sudden drops and low minima the trees will suffer all the more severely. As an example, the monthly mean temperatures at San Antonio are higher throughout the year than those of Fresno, Cal., or of Catania, in Italy, and excepting only the autumn months, higher than those of Sfax, in Tunis, three representative olive-producing regions. Yet the liability to the sudden advance of cold waves may upon experimentation be found to exclude this portion of Texas entirely from the olive-growing belt.

It seems probable also that there is a considerable difference in olive varieties in resistance to cold, and an inviting field for experimentation is here offered.

The high altitudes of the greater portion of New Mexico will doubtless exclude the olive on account of too severe cold. However, it seems probable that favored mesa sites may be found in the southwestern portion of the Territory, particularly in Grant and Dona Ana counties, where the olive may be grown.

French authorities[a] give the maximum range in altitude for the olive as from 500 meters (1,600 feet) in France and northern Italy to

[a] Investigation Made by the State Board of Horticulture of the California Olive Industry, Report to Governor Gage, 1900, p. 8.

700 meters (2,300 feet) in Sicily, it being even affirmed that it ascends as high as 800 meters (2,600 feet) on that island.

Simmonds, in his "Tropical Agriculture," states that the olive grows at Quito, under the equator, at a height of 8,000 feet above sea level.[a]

According to the reports of the California State Board of Horticulture[b] the olive does well at an altitude of 3,000 feet at 37 degrees latitude in the Sierra Nevadas. In the southern part of Arizona it is probable that it may thrive at still higher altitudes, possibly at 5,000 feet. Nor could a safety line of altitude alone be defined, for some higher spots favorably situated will be found to be more reliable than lower locations adjacent.

In California the olive grows well around San Diego, and from there along the coast northward to the upper end of the State and up into small valleys of the Coast Range. Farther inland the success would be limited by altitude, but it can be depended upon throughout upland portions of the greater area of the interior valleys and to altitudes of about 3,000 feet in the foothills. In Arizona areas of olive territory may be looked for as far north as the Gila River in Pinal County and farther west to the north line of Maricopa County, with probably the western limit at about the meridian of Gila Bend, on account of reduced rainfall. (See Table VIII.)

TABLE VIII.—*Localities in Arizona where dry-land olive culture may be possible, with meteorological record.*[c]

Station.	Length of record.	Altitude.	Mean annual temperature.	Minimum for 1908.	Date of killing frost, 1908. Spring.	Date of killing frost, 1908. Fall.	Precipitation, 1908.
	Years.	*Feet.*	° *F.*	° *F.*			*Inches.*
Congress	12	3,668	67.2	29	Feb. 4	Nov. 9	13.15
Columbia	10	1,900	68.2	29	Feb. 16	Nov. 25	15.40
Kingman	7	3,362	61.2	22	June 4	Oct. 18	11.77
Jerome	12	4,743	60.8	22	Apr. 17	Sept. 29	18.32
Cline	9	2,300	63.9	23	Apr. 9	Oct. 24	15.94
Globe	6	3,525	62.9	24	Mar. 28	Oct. 19	16.51
San Carlos	19	2,456	....	23	Apr. 4	Oct. 21	12.78
Phoenix	14	1,108	69.5	30	Mar. 8	Dec. 21	[d]7.88
Dudleyville	18	2,360	65.0	24	Mar. 23	Oct. 22	14.00
Tucson	28	2,390	67.5	22	...do....	Oct. 19	10.69
Benson	25	3,523	66.1	21	...do....	..do....	9.03
Oracle[e]	16	4,500	62.0	10	Mar. 29	Dec. 4	25.90
Tombstone	10	4,550	62.1	25	Feb. 28	Nov. 18	14.00

[a] "In the neighborhood of Quito, situated under the equator, at a height of 8,000 feet above the level of the sea, where the temperature varies even less than in the island climates of the temperate zone, the olive attains the magnitude of the oak, yet never produces fruit." —*P. L. Simmonds, Tropical Agriculture, p. 393.*

[b] Investigation Made by the State Board of Horticulture of the California Olive Industry, Report to Governor Gage, 1900, p. 8.

[c] Annual Summary, 1908, Arizona Section of the Climatological Service of the Weather Bureau.

[d] Mean annual, Weather Bureau, U. S. Dept. of Agriculture.

[e] Climatology of the United States, Bulletin "Q," Weather Bureau, U. S. Dept. of Agriculture.

AREA LIMITED BY HEAT REQUIREMENTS.

While the Pope olive grove has been studied as a case of survival without fruiting in spite of extreme adverse conditions, yet in the garden of Dr. Wellwood Murray at Palm Springs Hotel, with an ample shelter belt of trees around the border, two trees of the Pendulina variety have made a good growth and ripen fair crops of fruit with only scant irrigation, though there is scarcely a summer when a temperature of 120° to 122° F. is not recorded.

As to the maximum temperature which the olive will withstand, it is hard to find a locality in the United States where a fair degree of success may not be met with.

Contrary to the often-expressed opinion that it is only successfully grown in regions adjacent to the seacoast[a] the olive thrives and produces abundantly in such hot interior localities as Biskra, Algeria; Fresno, Cal.; and Phoenix, Ariz.

At Phoenix, Ariz., maximum summer temperatures of 112° to 116° F. are matters of record, with a July mean of 90° F. The mean temperatures for the months of June, July, August, and September are 6 to 9 degrees higher than those of Catania, the warmest olive-growing station of Italy,[a] and compare quite closely throughout the year with the mean of Biskra, Algeria. (See fig. 10.)

There is near Phoenix a small but flourishing olive industry under irrigation, the trees making a rapid, healthy growth and bearing good crops of olives, yielding oil of an excellent quality. This affords proof of the high temperature which the olive will sustain when that factor alone is taken into account.

There is an area through the more wind-exposed portions of the Colorado Desert where it is possible that the hot, dry winds of the early spring prevent, as a rule, the setting of the fruit, though the few trees to be found there make a fair growth with a minimum of irrigation.

For the development of the olive fruit a rather constant number of heat units above the dormant or zero point of the olive tree is needed during the active or growing season. For convenience in transcribing the data from weather records, however, these heat units are here assumed in degrees above zero, Fahrenheit. Thus, as the mean temperature of Phoenix, Ariz., has been determined after a number of years of recorded observations to be 52° F. for the month of January, multiplying 52 by 31, the number of days, gives 1,612, representing the number of heat units for that month. Computing each month in the same manner, their sum amounts to 25,607, the number of heat units for the year.

[a] Caruso, G. Dell' Olivo, Turin, 1883, p. 34.

Table IX shows the mean monthly and mean annual temperatures, with the sums of heat units for twelve localities of the olive-growing regions of Europe, Africa, and the United States, selected to show a range of temperatures from that at Bologna, Italy, with an annual mean of 57.16° F. and 20,895 heat units, which is slightly too cool, to that of Palm Springs, Cal., where there is probably about the extreme of heat which the olive will endure, it having an annual mean of 72.1° F. and a summation of 26,349 heat units.

TABLE IX.—*Mean temperatures and summation of temperatures, by months, at points in Algeria, Tunis, Sicily, Italy, Arizona, and California.*

Month.	Palm Springs, Cal.		Biskra, Algeria.[a]		Phoenix, Ariz.		Tucson, Ariz.		Sfax, Tunis.[b]		Catania, Sicily.[c]	
	Mean.	Summation.	Mean.	Summation.	Mean.	Summation.	Mean.	Summation.	Mean.	Summation.	Mean.	Summation.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
January	56.20	1,742	50.5	1,565.5	52	1,612	50	1,550	51.3	1,590.3	50	1,550
February	57.50	1,610	53.0	1,584.0	56	1,568	54	1,512	54.4	1,523.2	52	1,456
March	63.96	1,983	60.5	1,875.5	60	1,860	59	1,829	59.1	1,832.1	56	1,736
April	68.62	2,059	68.0	2,040.0	67	2,010	66	1,980	63.2	1,896.0	60	1,800
May	74.19	2,300	75.0	2,325.0	75	2,325	74	2,294	68.8	2,132.8	68	2,108
June	85.06	2,552	82.0	2,460.0	85	2,550	82	2,460	72.8	2,184.0	76	2,280
July	91.55	2,838	93.2	2,889.0	90	2,790	88	2,728	78.5	2,433.5	81	2,511
August	88.23	2,735	90.0	2,790.0	89	2,759	86	2,666	79.3	2,458.3	82	2,542
September	83.73	2,512	87.5	2,625.0	83	2,490	81	2,430	78.4	2,352.0	77	2,310
October	76.48	2,371	75.0	2,325.0	71	2,201	70	2,170	72.8	2,256.0	68	2,108
November	63.93	1,918	61.0	1,830.0	61	1,830	59	1,770	61.8	1,854.0	60	1,800
December	55.88	1,729	53.0	1,643.0	52	1,612	52	1,612	54.0	1,674.0	54	1,674
Year	72.10	26,349	70.7	25,952.0	70	25,607	68	25,001	66.2	24,186.2	66	23,875

Month.	Fresno, Cal.		Los Angeles, Cal.[d]		San Diego, Cal.		Pisa, Italy.[c]		San Jose, Cal.		Bologna, Italy.[c]	
	Mean.	Summation.	Mean.	Summation.	Mean.	Summation.	Mean.	Summation.	Mean.[e]	Summation.	Mean.	Summation.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
January	45	1,359	54.2	1,670.2	54	1,674	44	1,364	48	1,488	36	1,116
February	51	1,428	55.5	1,554.0	55	1,540	49	1,372	51	1,568	42	1,176
March	54	1,674	56.9	1,763.9	56	1,736	52	1,612	54	1,674	48	1,488
April	60	1,800	59.4	1,782.0	60	1,800	60	1,800	56	1,680	58	1,740
May	67	2,077	62.5	1,937.5	62	1,922	65	2,015	60	1,860	65	2,015
June	75	2,250	66.7	2,001.0	65	1,950	71	2,130	66	1,980	72	2,160
July	82	2,542	68.9	2,135.9	68	2,108	77	2,387	67	2,077	78	2,418
August	81	2,511	71.4	2,213.4	70	2,170	75	2,325	67	2,077	74	2,294
September	74	2,220	69.5	2,085.0	66	1,980	72	2,160	65	1,950	69	2,070
October	64	1,984	64.7	2,005.7	64	1,984	62	1,982	60	1,860	58	1,798
November	55	1,650	60.4	1,812.0	59	1,770	52	1,560	54	1,620	46	1,380
December	46	1,426	56.5	1,751.5	56	1,736	50	1,550	50	1,550	40	1,240
Year	63	22,921	62.3	22,712.1	61	22,370	60.75	22,257	58	21,384	57.16	20,895

[a] From Bulletin 53, Bureau of Plant Industry, U. S. Dept. of Agriculture, p. 64.
[b] From Bulletin 125, Bureau of Plant Industry, U. S. Dept. of Agriculture, p. 14.
[c] From "The Olive, Its Culture in Theory and Practice," by A. T. Marvin, San Francisco, 1888.
[d] Computed from data furnished by Mr. A. B. Wallaber, United States Weather Bureau, Los Angeles, Cal.
[e] Mean temperatures from "Climatology of the United States," Bulletin "Q", Weather Bureau, U. S. Dept. of Agriculture.

Caruso[a] states that the olive sap begins to stir at a temperature of 10.50° to 11° C. (which is equivalent to 51° to 52° F.) and flowers at 18° to 19° C. (equivalent to 64.4° to 66.2° F.). According to this author, we must regard the zero point of the olive as about 51° to 52° F., but the temperature figures in Table IX indicate that for such localities as Palm Springs and Los Angeles in California and Phoenix and Tucson in Arizona the zero point must be somewhat higher, probably 55° to 56° F.

To ripen the fruit within a period of safety from autumn frosts, there must be a sum of about 16,400 heat units within six or seven months from the starting of vegetation. Allowing seven months this would be equivalent to about 16,400 units from, say, the middle of March. In order to correlate this seasonal estimate with the summation of average annual heat units, as shown in Table IX, we will add to the above sum the number of heat units from January 1 to March 15 for Pisa, Italy, a typical olive locality, and we have a summation of 20,070 units, which would throw the olive ripening at Pisa to about November 20.

Hidalgo Tablada[b] gives the temperature for the flowering of the olive at 19° C. (66.2° F.) and states that at Seville this is reached about May 1. From that statement, the accumulation of 3,978 units C. (12,376 F., allowing one hundred and sixty-three days) is sufficient to mature the fruit, which will be accomplished early in October, after a growing season of 27.3° C. (81.14° F.) mean temperature. These dates of seasonal activity of the olive can be regarded only as approximations, there being variations due to localities as well as to varieties of fruit.

Data regarding the olive in relation to climate in the United States are rather meager, but what we have coincide in a very interesting way with the European observations.

Figure 10 is a graphical showing of the data of Table IX, summing up the heat units in columns for each locality, the monthly summations being carried between the heavy black lines across the chart. The heavy dotted horizontal lines show approximately the seasonal activity of the olive as it relates to these summations.

The phenological records for the olive at Phoenix, Ariz.,[c] for the year 1907–8 show the average date of full bloom of the olive to be

[a] Caruso, G. Dell' Olivo, Turin, 1883, p. 34.

[b] Hidalgo Tablada, José de. Tratado del Cultivo del Olivo en España y Modo de Mejorarlo, Madrid, 1899, p. 74.

[c] See the phenological records for Phoenix, Ariz., for December, 1907 and 1908, in the Arizona section of the Climatological Service of the Weather Bureau, U. S. Dept. of Agriculture.

about May 1, at mean temperatures of 66° to 71° F., shown by line *C*, figure 10.

The olive harvest is noted as beginning from October 8 to 10 and as completed during the latter part of December. The growing period from flower to earliest ripe fruit averages one hundred and sixty-three days at a mean temperature of 81.6° F., giving a summation of 13,314 units, which corresponds very closely with the figures of Caruso and Tablada. Adding the means, 7,050 units from January 1 to May 1, we have a total of 20,364 units.

For the full maturing of the crop of medium varieties, 24,000 to 25,000 units will be needed at this station, while late-maturing sorts will not ripen till well into the winter. Referring to the diagram (fig. 10) the line *D* indicates 20,364 units, which occur early in October

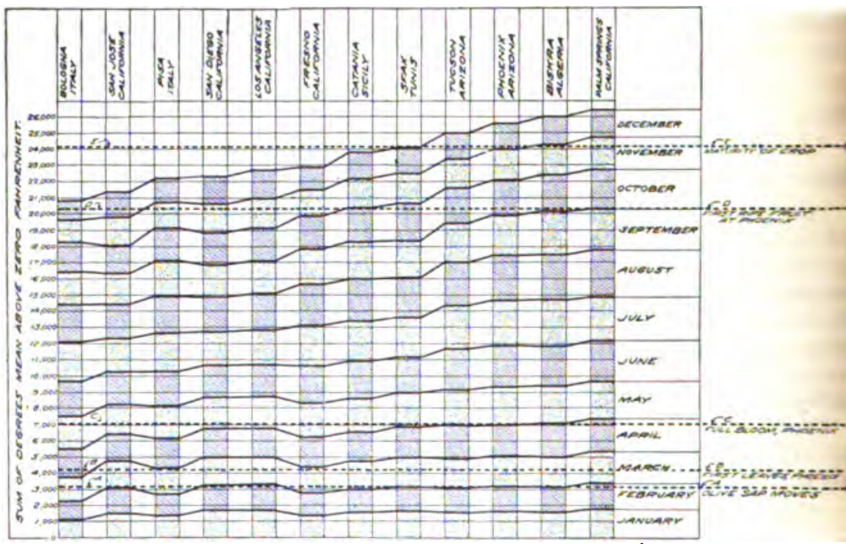

FIG. 10.—Diagram showing the monthly means and summation of heat units of places in the olive-growing regions, illustrating the seasonal activity and heat requirements of the olive, arranged from Table IX.

for Phoenix, late in November for Los Angeles and Fresno, and barely within the year at Bologna, Italy. Caruso states that the latter place is too cool for the olive, on account of the frosts of December and January, but that the fruit matures in sunny localities on the hillsides not far from the town. In localities having low summer means but with little or no frost in the winter months, such as San Jose and Santa Barbara, Cal., where the requisite number of heat units for the first ripening of the fruits will barely be accumulated by the end of December, the olives may remain on the trees throughout the succeeding winter months. Where the summation of about 21,000 degrees can not be reached before such low autumn temperatures prevail as will injure the fruit, olive growing should not be undertaken.

AREA LIMITED BY RAINFALL.

Taking up the consideration of rainfall, the industry must be considered from a different standpoint from that in which olive growing has been viewed in this country in the past. The usual planting distance has been from 20 to 24 feet. With abundant water the trees might prosper and produce remunerative crops with this area to draw from. When dependent upon local rainfall they have shown signs of failure.

In the valuable pamphlet on olive culture entitled "Investigation Made by the State Board of Horticulture of the California Olive Industry, Report to Governor Gage," 1900, page 29, is found a very significant discussion of the water problem by the Hon. Frank A. Kimball, the substance of which is as follows: Olive trees set at the ordinary orchard distance in this region, usually about 116 trees to the acre, gave during their earlier years very excellent results without irrigation. The growth was vigorous and the fruit large and fine.

Mr. Kimball gives a graphic account of their condition a few years later, as follows:

> The trees on becoming large required the necessary moisture to develop their growth, which had now assumed immense proportions. The soil could not furnish the requirements of the trees, and in the summer they lost the larger portion of their leaves. They remained in this semidormant condition until the rainy season set in or moisture from the soil began to rise. Most of the fruit dropped, and what did not fall did not attain a size suitable for picking. This condition of affairs continued until the growers resolved to apply water. After a season or more of demonstration they found irrigation to be one of the essential means through which a crop of fruit can be assured.
>
> The reason why we do not get olives is, the trees are starved, if want of water can be called starvation. For lack of water the soil can not furnish the material from which the olive is made.

The idea that the olive trees need a certain minimum volume of water for the performance of their physiological work is a fundamental one, but it does not seem to have occurred to these growers that by reducing the number of trees to the acre, thereby giving to each tree a sufficient area to afford the needed moisture, the same results might be secured as by irrigation. The olive has shown its ability to send out a root system that will secure the needed moisture from the larger area of soil and maintain a high productiveness. This has been shown by Mr. T. H. Kearney's study of the dry-land culture of the olive in Tunis, now accessible in Bulletin 125 of the Bureau of Plant Industry. From this publication we learn that a great olive-oil industry is carried on in Africa on lands receiving normally only from 9.3 to 15 inches of rainfall annually, while several good crops were produced during a period of seven years when the rainfall averaged only 6 inches, according to the French records.

The secret of this lies in wide planting, not more than 11 trees to the acre, and in clean cultivation, keeping the soil in a condition to receive every drop of rainfall and to conserve it to the utmost, the varieties used, chiefly Chemlali, being especially adapted to such conditions and affording a high percentage of oil.

The examples presented in this paper are those of the endurance of extremes of drought and neglect by varieties of the olive commonly grown in the south of Europe under conditions of sufficient, if not abundant, moisture. Their growth as trees in these arid situations in Arizona and California, interesting and suggestive as it is, would not warrant their maintenance as a commercial oil-producing enterprise. But the Chemlali and other varieties of the olive are profitably grown for oil production in the north of Africa without irrigation, and under conditions of soil and climate fairly comparable with those endured by the Arizona groves herein described. Whether the Chemlali variety will make the profitable growth in Arizona, California, and other sections of the Southwest that it has in Tunis can only be determined by careful experimentation.

The possibility that large areas of land within the proper temperature limits and having an ideal soil for the olive, yet without the rainfall or irrigation water necessary for ordinary crops, may be utilized for an olive-oil industry makes it worth while to institute experiments of sufficient extent to thoroughly test the matter. Plantings of more than an experimental character are not warranted by the present extent of our information, and the production of pickling olives is not contemplated.

In each of the instances cited where olive trees have remained alive and growing in spite of the failure of water it is necessary to remember that the plantation was established under irrigation. Likewise, in Tunis the truncheons by which the orchards are propagated are carefully watered by a supply carried from wells until sufficiently rooted to maintain themselves, three waterings usually being sufficient during the first summer. In making selections of tracts for olive culture over the drier areas indicated in Texas, Arizona, and California it must be a further condition of success that a small supply of water from some source can be assured to establish the young trees, after which a local rainfall of 7 to 12 or 15 inches annually may be expected to support the plantation and enable it to produce fair yields of fruit—perhaps enough to render dry-land olive culture profitable on a commercial scale.

SUMMARY.

In several localities in southern California and Arizona olive groves have been planted along with apricots, figs, grapes, and some other fruits. The irrigation projects under which these plantings were

made subsequently failed, leaving the fruit trees without any water other than the rainfall.

The local rainfall of 3½ to 8 or 10 inches annually has proved insufficient to maintain life in any of these plants except the olive, which has been found in many instances green and flourishing after six or eight years of abandonment and lack of irrigation.

Under these conditions the olive has shown the characteristics of a desert plant, competing with the mesquite, cat's-claw, and greasewood in their own territory. The plantations which have been studied are the Bogart-Degolia grove near Casa Grande, Ariz., a grove near Florence, Ariz., and "Las Palmas" trees in the olive belt northeast of Phoenix, localities having a mean annual rainfall of 7 to 9 inches; and in California, the Pope olive grove near Palm Springs, in the upper end of the Colorado Desert, where, with an annual average rainfall of only 3½ inches, 20 acres of olives have survived six years without irrigation and are still growing.

The soils of the localities are sandy and gravelly clays derived from the disintegration of the soft granitic rocks of the adjacent mountains. They are low in organic matter, but fairly rich in available phosphoric acid and potash. The soil at Palm Springs is a nearly pure granitic sand and gravel, very low in silt, clay, and humus, but showing by analysis percentages of potash and phosphoric acid equal to the better agricultural soils of the Mississippi Valley.

A study of the olive trees growing under these conditions has shown that unlike the mesquite and some other desert trees they do not survive by sending roots down to subterranean supplies of moisture, but develop instead a very elaborate system of roots occupying the soil at from 2 or 3 to 18 inches in depth and adapted to gathering moisture from the lightest rainfall.

The remarkable drought resistance of the olive is made possible (1) by the power these trees possess of extending their roots so as to gather moisture from a large area; (2) by their habit of growth in forming low spreading tops which protect the trunk and main branches from the burning heat of the sun; and (3) by the character of their leaves, which are constructed in a manner calculated to check evaporation and conserve the moisture obtained by the roots.

The plantations studied were made according to irrigation standards and contained originally from 75 to 114 trees to the acre. These plantings have proved too thick for successful growth without irrigation.

The varieties used in these orchards are the ones commonly grown under conditions of sufficient rainfall in France and Italy or with an abundance of irrigation in California.

The publication in 1908 of Bulletin 125 of the Bureau of Plant Industry, entitled "Dry-Land Olive Culture in Northern Africa," by Mr. Thomas H. Kearney, has brought to our attention the existence of a great oil-olive industry many centuries old, in the north of Africa, dependent on an average annual rainfall of 9.3 inches. The principal varieties grown are probably of local origin, adapted to these conditions through years of selection.

Very wide planting allows a great spread of roots for moisture gathering, while a system of clean cultivation and dust-mulch forming in vogue in that country before it was occupied by Europeans conserves to the utmost the meager rainfall.

The most drought resistant of these varieties, the Chemlali, has been imported by the Bureau of Plant Industry, and is being tested at a number of localities in the Southwestern States.

In view of the remarkable drought resistance shown by European olive varieties accustomed to abundant moisture, as shown in this bulletin, it is believed that with the planting of this desert-bred variety from Africa and the adaptation to our conditions of the Tunisian methods of planting and culture, large areas of land in the Southwestern States possessing a suitable soil and climate but now undeveloped from lack of irrigation water are adapted to produce olive oil.

Trial plantations are now being made at various points in this region to determine whether such dry-land olive culture will prove profitable on a commercial scale under American conditions.

APPENDIX.

ANATOMICAL STRUCTURE OF THE OLIVE (OLEA EUROPEA).[a]

By Dr. Theo. Holm.

ROOT STRUCTURE OF THE OLIVE.

Characteristic of the root structure of the genus Olea is the presence of stereome on the inner face of the pericambium and the prevalence of cambial cell divisions on the inner face of the leptome. Otherwise, the arrangement and development of the various tissues is not different from that of many other dicotyledons.

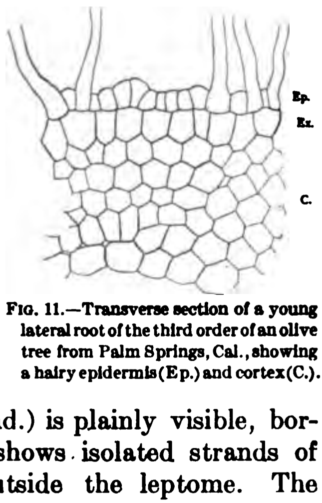

Fig. 11.—Transverse section of a young lateral root of the third order of an olive tree from Palm Springs, Cal., showing a hairy epidermis (Ep.) and cortex (C.).

The structure is as follows: In the young lateral roots of the third order (figs. 11 and 12) the epidermis (Ep.) is very hairy and covers an exodermis (Ex.) of thin-walled cells in a single layer; this exodermis is not contractile. The cortex (C.) is compact and thin walled; it consists of eight layers, more or less filled with starch; a thin-walled endodermis (End.) is plainly visible, bordering on the pericambium (P.) which shows isolated strands of stereome (St.) outside the leptome. The stele is tetrarch, there being four strands of leptome (L.) alternating with four rays of hadrome (H.), which extend to the center of the stele. Increase in thickness begins even in these thin roots, since cambial (Camb.) divisions are noticeable on the inner face of the leptome, although the increase does not extend beyond the formation of these few layers.

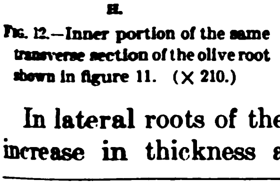

Fig. 12.—Inner portion of the same transverse section of the olive root shown in figure 11. (× 210.)

In lateral roots of the first or second order, on the other hand, the increase in thickness attains much larger dimensions, due to the

[a] This description of the anatomy of olive roots, leaves, and stems, with ten illustrations, was prepared at the writer's request by Dr. Theo. Holm, of Brookland, D. C., from material collected from several California groves.

activity of the pericambium in developing phellogen (Ph.) and cork (Co.) (fig. 13), besides a secondary cortex (C*) (fig. 14), to say nothing of the continued cambial cell divisions on the inner face of the leptome, as observed already in the much thinner lateral roots. The result of these various increases (fig. 14) is the development of a broad zone of cork, the development of a secondary cortex (C*), the development of a closed sheath of pericambial stereome (St.), and finally from the cambial strata the development of secondary leptome and hadrome (L. and H.) with rays of parenchyma (P.).

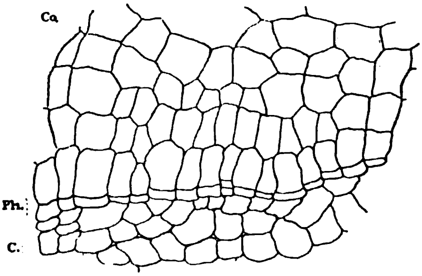

FIG. 13.—Transverse section of a lateral root of the first or second order of an olive tree, showing the development of phellogen (Ph.) and cork (Co.). (× 120.)

The diagram (fig. 15) shows the arrangement of all these tissues except the epidermis and the exodermis, which have, of course, been thrown off before this stage is reached. The center of the root possesses remnants of the primitive root stele, from which rays of parenchyma extend toward the sec-

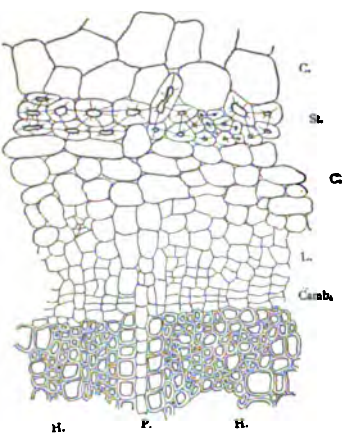

FIG. 14.—The same transverse section shown in figure 13 of the root of an olive tree, showing the development of a secondary cortex (C*) and parenchyma (P.) rays from the cambial (Camb.) strata. (× 120.)

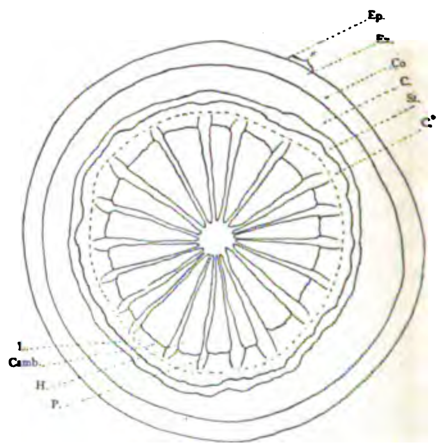

FIG. 15.—Diagram of the root of an olive tree, showing the general arrangement of tissues described in figures 11 to 14, inclusive. (× 22½.)

ondary cortex (C*). The root of the genus Olea shows the arrangement of the several tissues in a remarkably regular way, and the presence of pericambial stereome is interesting.

LEAF AND STEM STRUCTURE OF THE OLIVE.

The structure of the olive leaf is that of a xerophyte; in other words, it shows in a high degree peculiarities of structure that characterize most woody plants that grow in situations where both air and soil normally contain a relatively small amount of moisture. On the upper surface of the leaf the cuticle and outer walls of the epidermis cells are greatly thickened, stomata are absent, and shield-shaped hairs are scattered over the surface. On the lower face the outer walls of the epidermis cells are very thick (though less so than on the upper surface), the stomata are placed at the bottom of narrow pits, and shield-shaped hairs form a dense continuous covering. The interior, chlorophyll-bearing tissue (chlorenchyma) consists of three or four very compact layers of palisade cells (i. e., narrow cells, elongated at right angles to the epidermis) beneath the upper epidermis, and between the palisades and the lower epidermis many layers of so-called pneumatic tissue, the cells of which are very irregular in shape, not much longer than wide, and inclose numerous air spaces. Prosenchymatic cells with very thick walls (the stereome), either singly or in groups, are scattered through the mesophyll and occur here and there directly beneath the epidermis, as well as in several continuous layers adjoining the midrib. Between the midrib and the sheath of stereome there is no chlorenchyma, but extending to the epidermis on both sides are several layers of collenchyma, of which the cells contain no chlorophyll and have their walls greatly thickened, especially at the angles.

Of the foregoing characters, those which may be pointed out as especially xerophytic are: Thickness of the cuticle and outer cell walls of the epidermis, absence of stomata on the upper surface and their situation in pits on the lower face, and the dense covering of flat, shield-shaped hairs on the lower face. These characters are supposed to be especially useful to plants that inhabit dry climates or that grow in soils from which their roots obtain moisture with difficulty, by protecting the leaves from excessive loss of water through transpiration. The development of the chlorenchyma beneath the upper face of the leaf into several layers of compact palisade tissue is also characteristic of many xerophytes.

In leaves of the olive developed in the shade or in a moist atmosphere, the cell walls of the epidermis are much thinner, the stomata are level with the surface instead of being situated in pits, and the midrib is embedded in chlorenchyma, with a much smaller development of collenchyma.

Leaves and young twigs of olive trees were collected in abandoned orchards at Phoenix, Ariz., and at Palm Springs, Cal. In the former case the tree had been without irrigation for six years and in the latter

case seven years. Since in both cases the ground water was out of reach of the roots and since the average yearly rainfall in Phoenix is but 8.11 inches and at Palm Springs only 3.5 inches, it is evident that these leaves were produced under extremely arid conditions. In fact, the conditions at Palm Springs probably represent the extreme of drought that the olive tree can endure. In both cases the varieties were not identified. For purposes of comparison, similar material of the Mission olive, the variety most widely grown in California, was obtained at Niles, Cal., where the trees are irrigated at least once during the season and where the average yearly rainfall is 14.8 inches, with a low evaporation due to the cool summer climate. The leaf and stem structure of the last, which may be regarded as typical of *Olea europea* in the western United States, is as follows:

FIG. 16.—One of the peltate hairs from the surface of an olive leaf. (× 150.)

On the upper (ventral) face the cuticle is smooth and thick; the lateral walls of the epidermis cells, viewed superficially, are straight and very much thickened; stomata are wanting and peltate hairs (fig. 16) are scattered over the surface. On the lower (dorsal) face the cuticle is similar; the radial walls of the epidermis cells are almost straight, but not so much thickened as on the upper face; the numerous stomata (fig. 17) are sunken, with narrow and not very deep air chambers, and are surrounded by a variable number of undifferentiated epidermis cells; peltate hairs (fig. 16) are abundant, forming a continuous covering over the blade. The outer walls of the epidermis cells (figs. 17 and 18) are very thick on both faces of the leaf and show an increase in thickening very plainly. On the dorsal face they show many deepenings caused by the irregular thickening of the cell wall (fig. 17). The inner and radial cell walls of the epidermis are rather thin as compared with the outer walls. The unicellular stalks of the large shield-shaped hairs are located in circular cavities, the peltate part of the hair, which consists of numerous radially arranged cells, resting upon the outer wall of the epidermis.

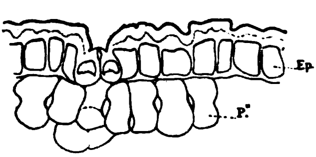

FIG. 17.—A sunken stoma and the uneven dorsal surface of an olive leaf.

The chlorenchyma is differentiated into palisade and pneumatic tissues. The former (fig. 18) consists of three compact layers of very high cells containing chlorophyll and small needle-shaped crystals of calcium oxalate. It extends from the margins of the blade to the midrib, where it ceases, being broken by the hypodermal collenchyma. On the dorsal side of the blade there is a thick pneumatic tissue of many layers. The cells which, like those of the palisade, contain

numerous needle-shaped crystals of calcium oxalate, are of a very irregular shape and the intercellular spaces are very wide (fig. 19). The pneumatic tissue, like the palisade tissue, is broken at the midrib by hypodermal collenchyma.

The stereome is thick walled and very unequally distributed. It occurs hypodermally (immediately beneath the epidermis) as single cells or a few cells together on both faces of the blade (fig. 18), as scattered cells in the collenchyma (Pl. V, fig. 1), and as a pericycle of several continuous layers in the midrib (Pl. V, fig. 1). It is characteristic of the genus Olea that the stereome cells traverse the pneumatic tissue in all directions (fig. 19). The pericylic stereome is thick walled only on the hadrome side of the midrib; on the leptome side it is thin walled with a very few thick-walled cells interspersed. The collenchyma (Pl. V, fig. 1) is hypodermal above and below the midrib and extends to the pericycle; it is generally thick walled, especially near the epidermis.

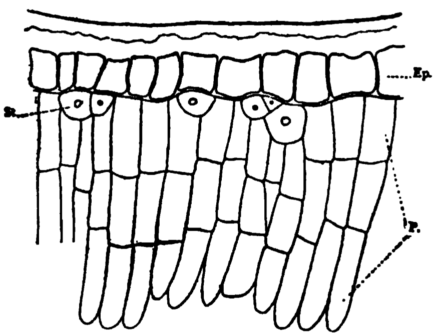

FIG. 18.—Ventral face of an olive leaf, showing the thickened walls of epidermal cells and palisade cells. (× 150.)

The mestome strands are, with the exception of the midrib (Pl. V, fig. 1), embedded in the chlorenchyma, and all the lateral strands are surrounded by thin-walled parenchyma sheaths, sometimes with a few adjoining stereome cells. The midrib has no parenchyma sheath and no endodermis, but, as previously described, it is surrounded by a thick sheath of stereome. All the mestome strands are collateral. The leptome forms an arch underneath the shorter but broader arch of hadrome. In the latter, each double row of vessels is separated from the next by a single row of parenchyma cells (parenchymatic ray).

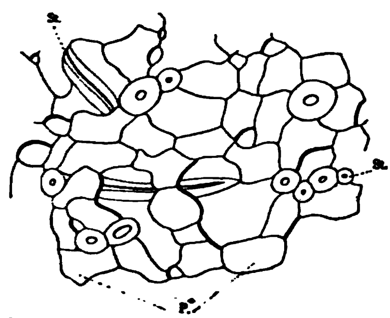

FIG. 19.—Pneumatic tissue of the dorsal side of a blade traversed by stereome cells. From a leaf of the Mission olive. (× 150.)

The petiole, examined at the characteristic point (where the mestome strands enter the leaf blade), shows a hemicylindric outline in cross section. It is covered with shield-shaped hairs, as is the blade, and the outer walls of the epidermis cells are extremely thick. The cortex is a solid mass of collenchymatic tissue and contains an arch shaped collateral mestome strand in the center. This mestor

strand has no support of stereome in the stricter sense of the word, but is simply surrounded by a small collenchymatic tissue. Leptome and hadrome show the same structure as in the midrib of the blade.

The arrangement of the tissues of the stem is shown in Plate V, figure 2. The cross section of the young twig is quadrangular and minutely four winged. The thin, smooth cuticle covers an epidermis with hairs similar to those of the leaf, and the outer cell walls are very thick; inside the epidermis are about twelve layers of cortical parenchyma, collenchymatic in the peripheral layers but more thin walled around the stele. Phellogen appears in the outermost layer of the cortex and soon develops several layers of cork, of which about three develop during the first summer. (Fig. 20.)

There is no endodermis, but a stereomatic and very thick-walled pericycle surrounds the stele. This pericycle, however, is not continuous, but consists of many strands of stereome separated by a few parenchymatic cells. The leptome presents a circular zone bordering on the pericycle, and is separated by cambium from the hadrome. The vessels (the scalariform ones especially) are thick walled and separated from each other by parenchymatic rays, each of a single row of rather thin-walled cells. The cells of the pith (which is solid) have thick porous walls and contain much starch.

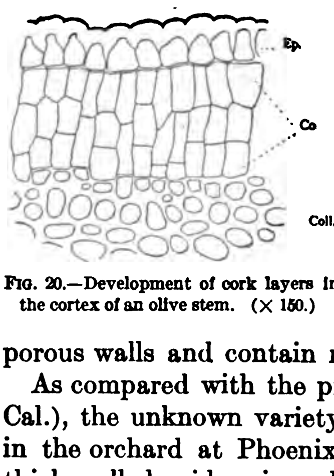

FIG. 20.—Development of cork layers in the cortex of an olive stem. (× 150.)

As compared with the preceding (the Mission variety from Niles, Cal.), the unknown variety of olive of which material was collected in the orchard at Phoenix, Ariz., is noteworthy for the extremely thick-walled epidermis on both faces of the leaf; thick-walled collenchyma extending from the epidermis to the pericycle of the midrib; more stereome in the pericycle; palisade and pneumatic tissues more compact but containing less stereome. In the petiole all the tissues are extremely thick walled. Cork develops very early in the stem, since even in the apical internode there are seven layers. The epidermis of the apical internode is extremely thick walled.

The two unidentified varieties collected in the abandoned orchard at Palm Springs appear to be identical in anatomical structure. From the variety growing at Phoenix they differ only in the much narrower midrib.

To summarize: The leaf and stem structure of the olive are such as to protect it admirably against excessive loss of water by transpiration and hence adapt it to growing in very dry soils and climates. The scanty evidence here presented would seem to indicate that the considerable difference in aridity represented by the two environments at Niles (where the average yearly rainfall is 14.8 inches, where moisture-laden winds blow in from the ocean, and where occasional irrigation is given) and of Palm Springs (where the average yearly rainfall is only 3.5 inches, where the air is excessively dry, and where the trees had received no irrigation for seven years) has a distinct, though comparatively slight, effect upon the anatomical structure of this plant, for even at Niles the olive exhibits in a high degree the characteristics of a xerophytic plant.

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DESCRIPTION OF PLATES.

PLATE I. Fig. 1.—One of the larger olive trees on the Bogart-Degolia plantation near Casa Grande, Ariz. Fig. 2.—Olive trees in the "Las Palmas" section, near Phoenix, Ariz., after six years of neglect and lack of water.

PLATE II. Fig. 1.—View in the Florence, Ariz., olive grove, about 16 years old, which has had no irrigation for the past six years. At the left, dead apricot and almond trees of the same age; at the right, olive trees in vigorous condition. Fig. 2.—Interior view in the grove shown in figure 1, showing a fine growth but thinner foliage than in the outer row shown in figure 1, due to the crowding of the trees.

PLATE III. Fig. 1.—View in the Pope olive plantation, near Palm Springs, Cal., after six years of neglect. Mean annual rainfall only 3½ inches. Fig. 2.—One of the larger trees, 8 feet high, in the Pope olive plantation, showing the low habit of growth and the protection of the trunk and main branches from heat by a canopy of foliage.

PLATE IV. Fig. 1.—Characteristic burl at the base of an olive tree on the Pope olive plantation, near Palm Springs, Cal. Fig. 2.—Feeding rootlets, natural size, from 6 inches in depth, on the same plantation shown in figure 1.

PLATE V. Fig. 1.—Cross section of the midrib of the leaf of Olea europea (Mission variety), showing the epidermis, palisade tissue, massively developed collenchyma, pericyclic stereome, hadrome, leptome, and pneumatic tissue. Magnified 180 times. Fig. 2.—Cross section of one of the apical internodes of the stem, showing the epidermis, hypodermal collenchyma, stereome ring, leptome, hadrome, and pith. Magnified 112 times.

PLATE VI. Fig. 1.—View in a 500-acre olive plantation in southern Los Angeles County, near La Mirada, Cal., grown without irrigation. The planting distance of 20 feet each way is much too close for the full development of the trees. Fig. 2.—View in a different part of the plantation shown in figure 1, where the trees have been thinned by removing alternate diagonal rows. The conditions are consequently much improved.

FIG. 1.—ONE OF THE LARGER OLIVE TREES ON THE BOGART-DEGOLIA PLANTATION, NEAR CASA GRANDE, ARIZ.

FIG. 2.—OLIVE TREE AT "LAS PALMAS," NEAR PHOENIX, ARIZ., AFTER SIX YEARS OF NEGLECT.

FIG. 1.—VIEW IN THE OLIVE GROVE AT FLORENCE, ARIZ., SHOWING DEAD APRICOT AND ALMOND TREES IN CONTRAST WITH FLOURISHING OLIVES AFTER SIX YEARS WITHOUT IRRIGATION.

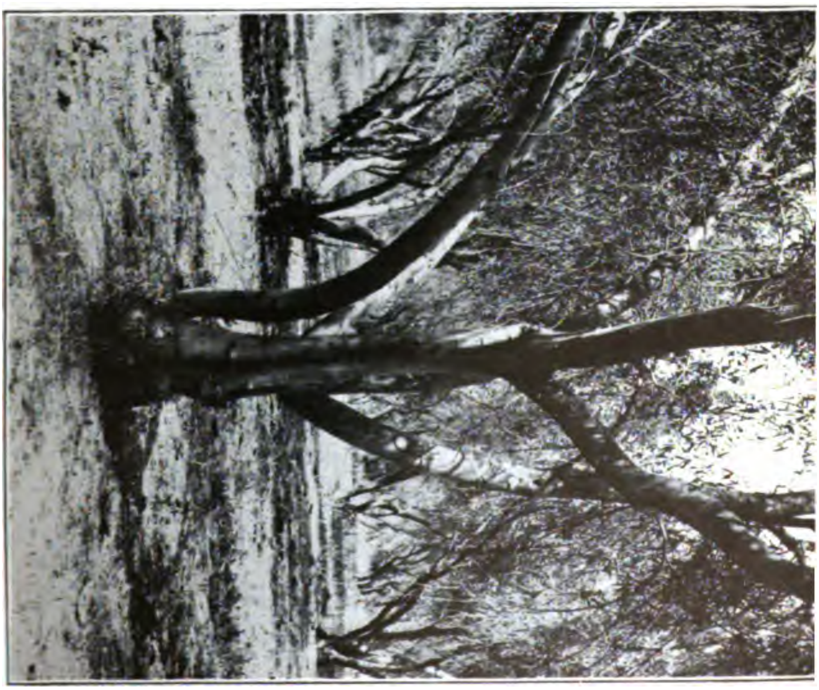

FIG. 2.—INTERIOR VIEW IN THE GROVE SHOWN IN FIGURE 1, THE FOLIAGE, ON ACCOUNT OF CROWDING, HAVING BECOME THINNER THAN THAT OF THE OUTER ROW.

FIG. 1.—VIEW IN THE POPE OLIVE PLANTATION, NEAR PALM SPRINGS, CAL., AFTER SIX YEARS OF NEGLECT.

FIG. 2.—ONE OF THE LARGER TREES IN THE POPE OLIVE PLANTATION, SHOWING THE LOW HABIT OF GROWTH OF THE TREES.

FIG. 1.—CHARACTERISTIC BURL AT THE BASE OF AN OLIVE TREE ON THE POPE PLANTATION, NEAR PALM SPRINGS, CAL.

FIG. 2.—FEEDING ROOTLETS, FROM 6 INCHES IN DEPTH, ON THE POPE OLIVE PLANTATION. (NATURAL SIZE.)

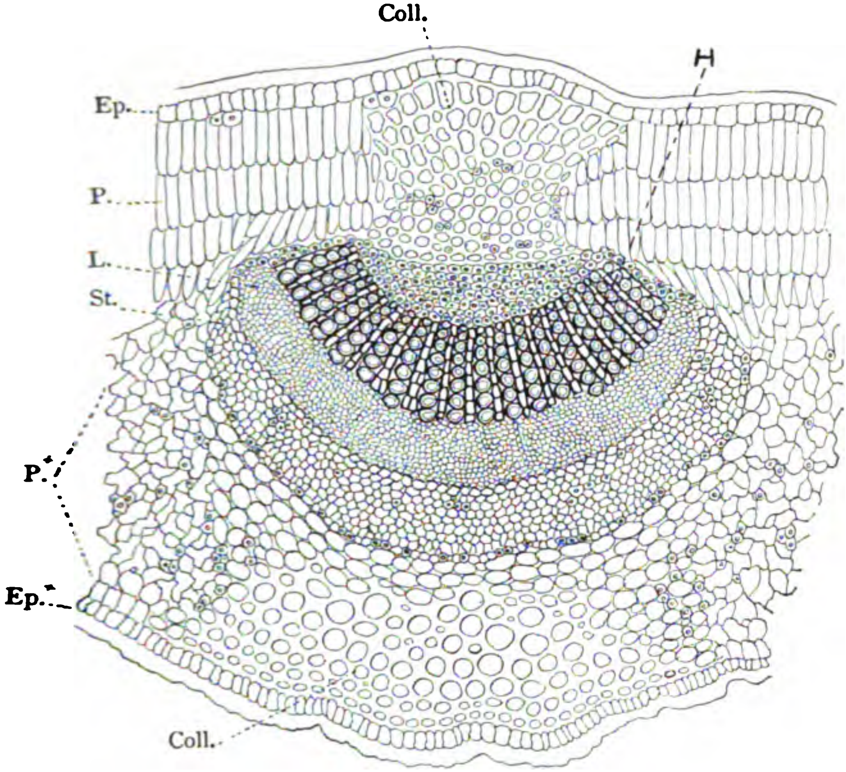

FIG. 1.—CROSS SECTION OF THE MIDRIB OF THE LEAF OF OLEA EUROPEA (MISSION VARIETY).

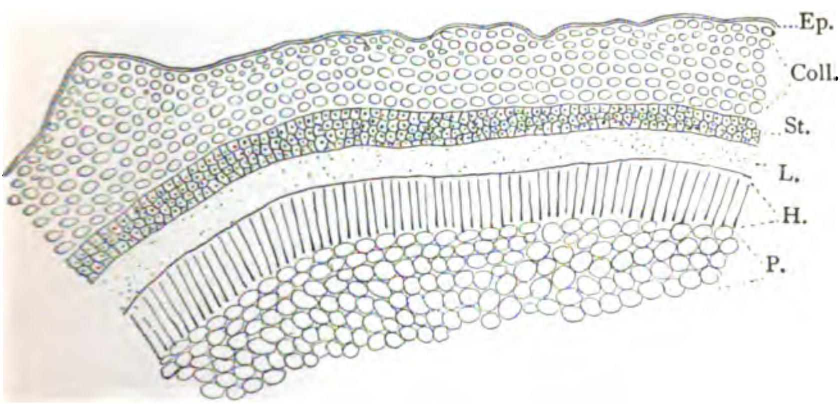

FIG. 2.—CROSS SECTION OF ONE OF THE APICAL INTERNODES OF THE STEM OF OLEA EUROPEA (MISSION VARIETY).

FIG. 1.—VIEW IN THE 500-ACRE OLIVE PLANTATION NEAR LA MIRADA, CAL.

FIG. 2.—VIEW IN A DIFFERENT PART OF THE PLANTATION SHOWN IN FIGURE 1, WHERE THE TREES HAVE BEEN THINNED BY REMOVING ALTERNATE DIAGONAL ROWS.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 193.

B. T. GALLOWAY, *Chief of Bureau.*

EXPERIMENTS IN BLUEBERRY CULTURE.

BY

FREDERICK V. COVILLE,

Botanist in Charge of Taxonomic and Range Investigations.

Issued November 15, 1910.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1910.

BUREAU OF PLANT INDUSTRY.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., July 19, 1910.

SIR: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 193 of the series of this Bureau a manuscript by Mr. Frederick V. Coville, Botanist in Charge of Taxonomic and Range Investigations, entitled "Experiments in Blueberry Culture." Mr. Coville has found by experiment how blueberries differ from ordinary plants in their method of nutrition and in their soil requirements, and by means of this knowledge he has worked out a system of pot culture under which these plants attain a development beyond all previous expectations. There is good prospect that the application of the knowledge thus gained will establish the blueberry in field culture and that ultimately improved varieties of these plants will be grown successfully on a commercial scale.

A particularly interesting and significant feature of these experiments is the light they shed on the possible utilization of the naturally acid lands that occupy extensive areas in the eastern United States. These lands are generally valued at a low price, and the chief expense involved in their utilization for ordinary agricultural crops is the cost of correcting their acidity and its effects by liming, fertilizing, and cultural manipulation. The question presents itself, "May we not more effectively utilize such lands by growing on them crops which, like the blueberry, thrive in acid soils?"

Some of the experimental methods and equipment utilized by Mr. Coville are commended to other plant experimenters, especially the use of darkened and drained glass pots for the intimate observation of the behavior of roots, and the plunging of pots in moist sand to maintain equable moisture and aeration conditions.

Respectfully,

WM. A. TAYLOR,
Acting Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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EXPERIMENTS IN BLUEBERRY CULTURE.

INTRODUCTION.

In the grounds of the Smithsonian Institution at Washington are two blueberry bushes of large size and great age. The taller is about 9 feet high. The largest stem is nearly 3 inches in diameter. It is known that these bushes were growing prior to 1871, thirty-nine years ago, and all the evidence indicates that they were planted at a much earlier date. They are probably over 50 years old.[a] In the Arnold Arboretum, near Boston, are many blueberry bushes 30 years old or more, grown from the seed by Mr. Jackson Dawson or transplanted from their wild habitats prior to 1880.

The two cases here cited demonstrate the fallacy of the popular idea that the blueberry can not be transplanted or cultivated. This idea rests on the unsuccessful experience of those who have taken up wild bushes and set them in a rich, well-manured garden soil. These are exactly the conditions, as shown by experiments described in this publication, under which blueberry plants become feeble and unproductive.

Four agricultural experiment stations, those of Maine, Rhode Island, New York, and Michigan, have attempted to grow the blueberry as a fruit, but none of these attempts has resulted in the commercial success of blueberry culture, and the experimental results have been chiefly of a negative character. This outcome appears to have been due to a misunderstanding of the soil requirements of the blueberry, which, as will be shown later, are radically different from those of our common cultivated plants.

[a] The plants are *Vaccinium atrococcum*, a species closely related to *Vaccinium corymbosum*, the well-known swamp or high bush blueberry of the Northern States. In a list of the trees and shrubs of the Smithsonian grounds prepared by Arthur Schott in 1871, these bushes are included, but identified, however, as *Vaccinium fuscatum*. The late Mr. George H. Brown, for more than a generation the superintendent of planting in the parks of Washington, also assured the writer that these plants were not set out since he first became responsible for the Smithsonian grounds, in 1871. The present plan of the grounds was made by Mr. Andrew J. Downing, but the actual planting was not done until after his death, in 1852. It is possible that the blueberry bushes may have been set out as early as 1848, in which year a partial planting of the Smithsonian grounds was made by Mr. John Douglass.

In the Boston market there is a wide variation in the wholesale price of blueberries. Shipments begin in early June from North Carolina, followed in the latter part of the month by blueberries from Pennsylvania, New Jersey, and New York. In early July, or in some years in the last days of June, Massachusetts and New Hampshire shipments begin to arrive, succeeded in late July or early August by berries from Maine, Nova Scotia, and New Brunswick. Receipts from these last two localities continue until late September. The blueberries that bring the highest price are those from Massachusetts and New Hampshire. At the time when other berries are selling at 8 to 15 cents per quart wholesale, the first shipments of New Hampshire berries often bring 20 to 23 cents.

The owner of a blueberry pasture in southern New Hampshire who superintended the picking of his own berries and shipped them to one of the secondary New England cities has courteously shown his shipment records, from which the following data have been compiled:

Records of shipments from a blueberry pasture in southern New Hampshire, 1905–1909.

Year.	Date of shipment.	Total shipments.	Highest and lowest price per quart.[a]	Average price per quart.[a]
		Quarts.	*Cents.*	*Cents.*
1905	July 1 to Aug. 14	2,233	12½ to 8	10.7
1906	July 17 to Aug. 15	2,756	15 to 8	9.6
1907	July 20 to Aug. 15	2,538	14½ to 11	12.2
1908	June 29 to Aug. 15	3,602	16 to 9½	10.8
1909	July 15 to Aug. 16	1,255	14 to 9	10.7

[a] This is the net price that the shipper received after deducting express charges.

The average net price for the five years was 10.8 cents per quart. The record indicates the substantial returns that are secured from ordinary wild berries picked and sent to market in rather better than ordinary condition.

That the market would gladly pay a high price for a cultivated blueberry of superior quality there can be no doubt. From the market standpoint the features of superiority in a blueberry are large size; light-blue color, due to the presence of a dense bloom over the dark-purple or almost black skin; "dryness," or freedom from superficial moisture, especially the fermenting juice of broken berries; and plumpness, that is, freedom from the withered or wrinkled appearance that the berries begin to acquire several days after picking. While the connoisseur in blueberries who picks his own fruit knows the widely varying flavors in the berries of different bushes, the buyer in the city market is content to select his fruit according to its appearance, knowing that the flavor will be good enough in any event.

The size of the seed gives the buyer in New England markets very little concern, for there the name blueberry is restricted to plants of the genus Vaccinium, all of which have seeds so small as to be unnoticeable when the berry is eaten, while the name huckleberry is applied with nearly the same precision to the species of the genus Gaylussacia, in which the seed is surrounded by a bony covering like a minute peach pit, which crackles between the teeth. In southern cities the fruits of both Vaccinium and Gaylussacia are called huckleberries, and it is probable that the low estimation in which the fruit of Vaccinium is there held is largely due to the lack of a distinctive popular name. To distinguish the two berries by their appearance is difficult for any but an expert, for while huckleberries are mostly black and blueberries mostly blue, some of the blueberries, or species of Vaccinium, are black, and some of the huckleberries are blue, notably *Gaylussacia frondosa*, a species often abundant in the sandy soils of the Atlantic Coastal Plain, which has a large, handsome berry of a beautiful light-blue color and passable flavor, but with the disagreeably crackling seed pits characteristic of the other true huckleberries.

The blueberry withstands the rough treatment incident to shipment so much better than most other berries that with proper handling it should always reach the market in first-class condition. But its good shipping qualities are often abused, and the fruit not infrequently is exposed for sale partly crushed and the berries covered with soured juice and made further offensive by the presence of flies. This is the prevailing condition of blueberries and huckleberries in the markets of Washington, in striking contrast with the dry, plump berries of the Boston market. This bad condition is due usually to improper picking.

The small size of the blueberry, compared with other berries, renders the picking of it expensive. The owners of blueberry pastures commonly pay two-thirds the net price of the berries to their pickers. In order to reduce the cost of picking, various devices have been employed. The most widely used of these is an implement known as a blueberry rake, a scoop shaped somewhat like a deep dustpan, provided in front with a series of long, pointed fingers of heavy wire. With this implement an ordinary picker in the blueberry canning districts of Maine, for example, gathers 3 to 5 bushels a day, for which he receives 1¾ to 2 cents per quart. Blueberries can be picked with a rake at about a fourth the cost of picking by hand. For this reason many of the berries that go to market are picked with a rake, and it is these berries which, broken and fermenting, make up the greater part of the low-grade stock so offensive to the eye and the taste. Blueberries intended for the market should never be picked with a rake.

What has been said regarding the high cost of picking ordinary blueberries by hand indicates the importance of securing a berry of large size if the plant is to be cultivated. Large size and abundance mean a great reduction in the cost of picking. Large size means also a higher market price, and when taken in connection with good color and good market condition it means a much higher price.

The writer's interest was attracted to the subject of blueberry culture in 1906. In the autumn of that year some experiments were made for him by Mr. George W. Oliver to ascertain a suitable method of germinating the seeds. In the autumn of 1907 special cultural experiments were taken up. In 1908 experiments were begun in the propagation of bushes bearing berries of large size, the most satisfactory of these being a New Hampshire bush of the swamp blueberry (*Vaccinium corymbosum*) having berries a little more than half an inch in diameter. The largest berries tried, a little more than five-eighths of an inch in diameter, were from Oregon bushes of *Vaccinium membranaceum*. Except where otherwise stated, the experiments described in this paper were made with *Vaccinium corymbosum*. The principal results of the experiments are given under brief numbered statements, each followed by a detailed explanation.

PECULIARITIES OF GROWTH IN THE BLUEBERRY PLANT.

SOIL REQUIREMENTS.

(1) THE SWAMP BLUEBERRY DOES NOT THRIVE IN A RICH GARDEN SOIL OF THE ORDINARY TYPE.

Although the statement just made might well rest on the direct observation of experimenters who have failed to make blueberries grow luxuriantly, or sometimes even remain alive, in rich garden soils, nevertheless the citation of one of the writer's experiments may serve to accentuate the fact. The soil chosen for the purpose was the one used at the United States Department of Agriculture for growing roses. A sample of this soil, as mixed by the rose gardener, consisted, according to his specifications, of "five shovelfuls of loam, one shovelful of cow manure, and a handful of lime." The loam used was a rotted grass turf grown on a rather clayey soil. The cow manure was well rotted, having lain in the pile for several months, with almost no admixture of straw. The lime was of the ordinary air-slaked sort.

The pots used in the experiment were of glass, small 5-ounce drinking glasses, about 2 inches in diameter at the bottom, 2½ at the top, and 2¾ inches deep. A small hole bored through the bottom gave the necessary drainage to the soil in the pot. Since the walls of these pots were transparent, the normal growth of the roots and the pre-

vention of an obscuring green growth of microscopic algæ required some arrangement for keeping the light away. This was accomplished either by sinking, or, as gardeners say, "plunging," the pots nearly to the rim in sand, moss, or soil, or, when the pots were not plunged, by fitting closely to the outside of each a removable cuff, as it were, made of the opaque gray blotting paper used in pressing specimens of plants. The use of a pot with transparent walls was found to be of very great importance in the study of these plants, for plants identical in appearance so far as the parts above ground were concerned sometimes showed the most pronounced differences in the growth and behavior of the roots, differences which otherwise would not have been observed but which were in reality responsible for the conspicuous changes that later took place in the growth of the stems and leaves. The use of such glass pots, drained and darkened, is strongly recommended to plant experimenters who use pot cultures, as they afford a means of acquiring easily an intimate knowledge of the great variations in the behavior of the feeding organs, the roots, under different conditions.

On December 22, 1908, six glass pots were filled with the garden soil described above, and a seedling blueberry about an inch in height was transplanted into each. The seed bed from which the seedlings were taken had been allowed to become partially dry before the transplanting was done. In this condition there was no difficulty in removing all of the sandy soil adhering to the roots of a seedling, so that after it was transplanted it must derive its soil nourishment from the new soil exclusively. In potting, the roots of the plant were laid against the glass on one side of the pot so that their behavior could be observed from the very first.

A transplanting of six other plants was then made, similar in all respects to the first except that the soil used was a peat mixture known from earlier experiments to be productive of vigorous growth in blueberry plants. The exact character of this soil will be discussed later in this publication.

This peaty blueberry soil is ill suited to the growth of ordinary plants, while in the garden soil ordinary plants flourish luxuriantly. In order to bring out this fact clearly by an experiment six glass pots containing this garden soil were planted with five alfalfa seeds each, and six more with one rooted rose cutting each. An identical planting was made in twelve pots of blueberry soil.

Average examples of the growth that took place in these plantings are shown in figures 1 to 6, reproduced from drawings carefully made from actual photographs. In the garden soil the rooted rose cutting, which was of the variety known as Cardinal, made vigorous growth of both root and stem, and in forty-four days, when the

photograph was taken, had about quadrupled its leaf surface. In the blueberry soil the cutting was barely alive, the roots it had at the time it was potted were nearly all dead, no new stem growth had been made, and the leaflets it bore were only those still persisting from the parent plant.

The alfalfa seeds began to germinate in both soils in three days At the end of a week a distinct difference in the color of the plant was discernible. In the blueberry soil the seed leaves were darke green in color, the midrib, which shows on the back of the leaf, wa

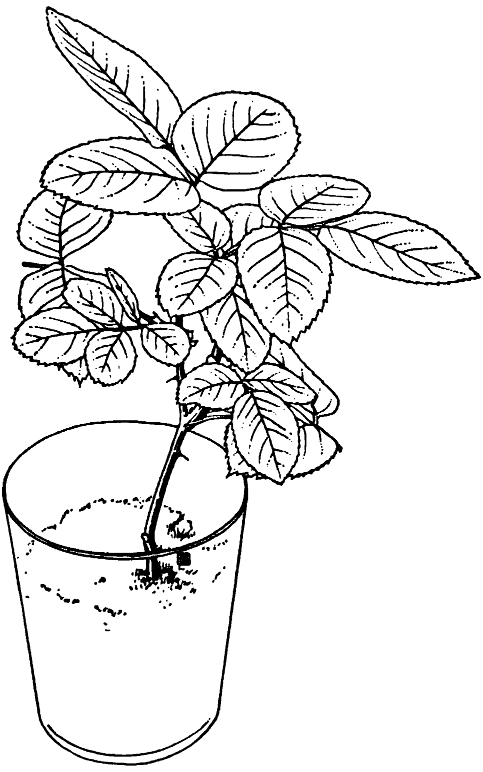


FIG. 1.—Rose cutting in rich garden soil. (One-half natural size.)

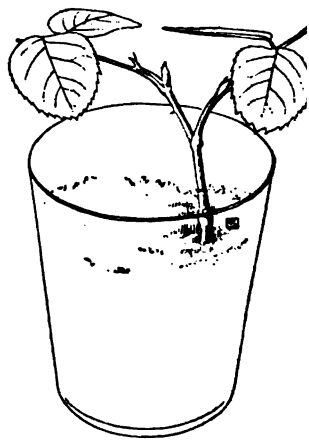


FIG. 2.—Rose cutting in peat mi ture. (One-half natural size.)

purple, the stem was purple, and in some of the seed leaves the who under surface was purple. In the garden soil the seed leaves we lighter green in color, and in only a few were the stems, and in sti fewer the midribs, somewhat purplish. At the end of forty-four day when the photographs reproduced in figures 3 and 4 were taken, th alfalfa plants in the garden soil were 3 inches in height and vigorou while the soil was crowded with roots on which nitrogen tubercl had already begun to develop. In the blueberry soil the plants we small leaved and sickly, about a third the height of the others, an

the roots though long were slender and otherwise weak and bore no tubercles.

In the case of the blueberry plants the relative growth in the two soils took exactly the opposite course. At the end of the first week new root growth had begun in all the pots containing blueberry soil, while in those containing garden soil new root growth was apparent in only one. At the end of forty-four days vigorous root growth had taken place in the blueberry soil pots, and stem growth, which had been interrupted at the time of transplanting, was well under way again. In the garden soil, however, almost no root growth was discernible, the old leaves were strongly purpled and stem and leaf growth had not been resumed. Little attention was paid to these cultures during the summer of 1909, but the relative condition of the two is fairly

FIG. 3.—Alfalfa seedlings in rich garden soil. (One-half natural size.)

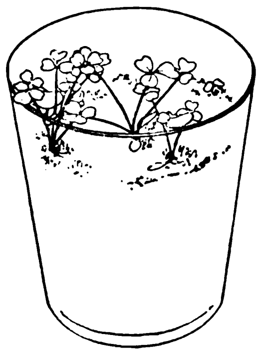


FIG. 4.—Alfalfa seedlings in peat mixture. (One-half natural size.)

illustrated in figures 5 and 6, from photographs taken November 22, 1909, after the leaves had fallen. The garden-soil pot contained only a few stray roots, and the slender stems were only 2 inches high. The pot containing blueberry soil was filled with a dense mass of roots, and although the plant had not been repotted when it needed repotting, the largest stem was nevertheless 11 inches long and the weight of that part of the plant above ground was fifty-one times that of the corresponding part of the garden-soil plant.

(2) THE SWAMP BLUEBERRY DOES NOT THRIVE IN A HEAVILY MANURED SOIL.

In May, 1909, two healthy and vigorous blueberry seedlings were sent for trial to one of the agricultural experiment stations. They were set out in a soil that was known to be suitable for these plants, for old blueberry bushes had been growing there for several years.

The man who put the blueberry seedlings in the ground, however, misunderstanding the directions sent him, filled in the holes in which he set the plants with alternate layers of soil and well-rotted stable manure. The writer examined the plants on August 27, 1909, when they should have been either growing vigorously or, with mature foliage, ripening their wood for the winter. Instead they had lost nearly all their older leaves though still maintaining a feeble and spindling growth at the ends of the larger stems. The adjacent old bushes growing in precisely the same soil, except that it had not received the heavy application of manure, bore at the same time vigorous dark-green foliage and were ripening the wood of their stout twigs and laying down their flowering buds for the following year. The manured plants when dug up and examined showed no new root growth whatever in the manured soil outside the old earth ball, and most of the roots on the surface of the ball itself were dead.

Another experiment may be cited to show the injurious effect of heavy manuring. On December 22, 1908, six blueberry seedlings were transplanted into as many glass pots in a good blueberry soil, and six other seedlings were potted in the same manner, except that to each two parts of blueberry soil one part of well-rotted but unleached cow manure was added. At first the manured plants appeared, superficially, to be doing better than those not manured, for in the former the production of new leaves and the continued growth of the stem tip

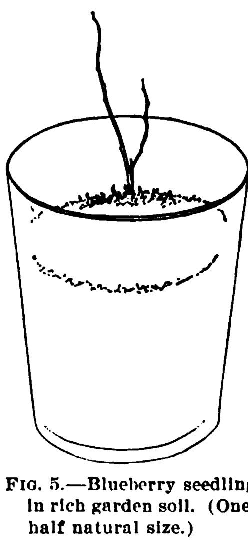


Fig. 5.—Blueberry seedling in rich garden soil. (One-half natural size.)

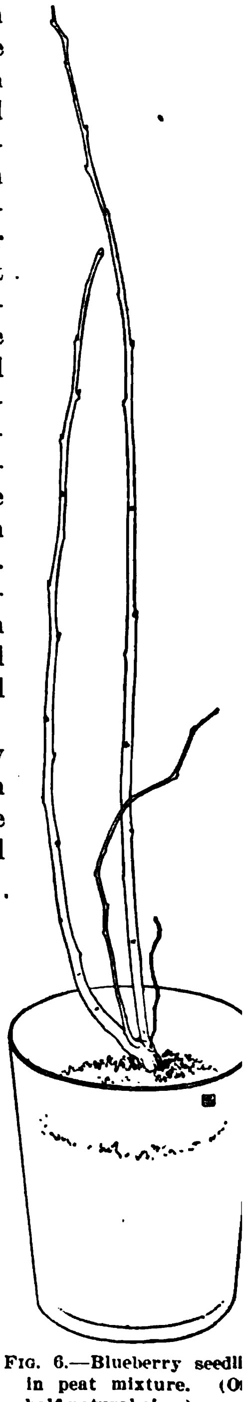


Fig. 6.—Blueberry seedli in peat mixture. (O half natural size.)

were not interrupted by the potting, while in the plants not manured there was a temporary but definite stopping of stem growth immediately after the potting. The apparent superiority of growth in the manured plants, above ground, continued for about three weeks. Below ground, the roots of the two cultures showed directly opposite results. In the plants without manure, new root growth began a few days after potting. At the end of three weeks the development of an extensive root system was well under way and the plants were nearly ready for a period of vigorous stem growth. In the manured plants, however, either no root growth took place or only a slight amount, the new rootlets being fewer, shorter, and stouter than in normal plants. The old rootlets turned brown and appeared to be dead or dying. (See p. 64.) At the end of five weeks the growth of the tops was very slow. About ten days later, on February 6, a bright warm day, the lower leaves on three plants withered, and within a few weeks all six of the manured plants were dead.

(3) THE SWAMP BLUEBERRY DOES NOT THRIVE IN A SOIL MADE SWEET BY LIME.

In its natural distribution the blueberry, like almost all plants of this and the heather family, avoids limestone soils. The fertile limestone areas of western New York, of Ohio, of Kentucky, and of Tennessee lack the blueberry, the huckleberry, the laurel (*Kalmia latifolia*), and the trailing arbutus (*Epigaea repens*). The State of Alabama, as described by Charles Mohr in volume 6 of Contributions from the United States National Herbarium, is traversed from east to west in the general latitude of Montgomery by a strip of dark calcareous soil, 35 to 45 miles in width, the so-called "black belt," which constitutes the great agricultural region of the State. The noncalcareous areas north and south of this strip have in their forests a characteristic undergrowth of blueberries and closely related plants, including huckleberries, farkleberries, and deerberries. In the intermediate belt of black limestone soil, just described, the plants of blueberry relationship are almost wholly wanting.

In an article entitled "The Soil Preferences of Certain Alpine and Subalpine Plants,"[a] Mr. M. L. Fernald discusses the natural distribution of over 250 species of plants found in the cold parts of the northeastern United States and Canada. All the blueberries he enumerates, five species, avoided calcareous soils, and the other plants of the blueberry and heather families almost without exception occurred likewise on noncalcareous formations.

The writer's own experiments in growing blueberries in limed soils have not proceeded with the same smoothness as some of his other experiments, but the results, though at first misleading, have uniformly been exceedingly instructive, though not always in the

[a] Rhodora, vol. 9, 1907, pp. 149–193.

direction originally contemplated, and in the end have been fully conclusive.

On May 26, 1908, six blueberry seedlings were potted in six 14-ounce drinking glasses in a good peaty blueberry soil, in which, however, 1 per cent of air-slaked lime [a] had been mixed immediately before the potting was done. Six other plants were similarly potted, but without the addition of lime. The unlimed plants grew normally. The younger leaves of the limed plants, however, began to wilt the same day on which they were potted. On June 1 all the leaves on all six plants were withered, though parts of the stems were still green and plump. The leaves did not turn purplish or yellowish, as is usual with sickly blueberry plants, but either retained their green color after withering or turned brown. No new root growth took place in any of the limed pots, and by July 10 all the plants were dead.

Another series of six plants, also potted on May 26, 1908, but in a sterile soil containing no peat, by accident received a very small amount of lime. Most of the leaves on these plants withered during the first few days, but the plants subsequently recovered and made as good growth as could have been expected from the general character of their soil.

From these experiments the writer concluded that the blueberry was exceedingly sensitive to lime and that the slightest admixture of it in the soil would be immediately fatal to the life or at least the health of a blueberry plant. This conclusion, however, was erroneous, as subsequent experience showed. This first experiment may therefore be dismissed with the explanation that in all probability the immediate collapse of the plants was due to a caustic effect of the lime used. In none of the later lime experiments did this immediate collapse occur and in none was the lime so applied that it came into contact with the blueberry roots while in a caustic condition.

Still laboring under an erroneous conception of the supersensitiveness of the blueberry plant to minute quantities of lime, the writer, desiring to produce fresh examples of this phenomenon, in November, 1908, placed a very small quantity, a few milligrams, of air-slaked lime on the surface of the soil in each of three 2-inch pots containing a small blueberry plant. No effect was produced either at first or for several weeks. On December 19, 1908, a large surface application of carbonate of lime was made to the same three plants, a gram to each pot, and the lime was washed down with water. The expected collapse did not occur. The limed plants continued to grow as luxuriantly as their unlimed neighbors. The con-

[a] Computed on the dry weight of the soil.

clusion was reached that the reason why the growth of the plants had not been affected was because the lime had not penetrated sufficiently into the soil. Another and more drastic experiment was therefore determined upon.

On March 10, 1909, six blueberry plants in 4-inch pots containing a good blueberry soil were set apart from their fellows and watered with ordinary limewater, a saturated solution of calcium oxid, 1.25 grams per liter of water. The applications made were of such an amount that the soil in the pot was thoroughly wetted each time, and usually a small excess quantity ran through the hole in the bottom of the pot.

For more than seven months, until October 22, 1909, these pots received no other water than limewater. During this period the plants continued to grow in a normal manner, their average height increasing from 4½ to 14 inches. The lime appeared to have no deterrent effect whatever on the growth of the plants. A computation based on the total amount of limewater used showed that each pot must have received about 18 grams of lime. An analysis of the soil in one of the pots after the limewater applications had ceased gave 14 grams. This amount was enormous, considered from the standpoint of agricultural usage. The soil, which had about one-third the weight of an ordinary soil, was over 8 per cent lime. This is the equivalent of about 25 tons of lime per acre mixed into the upper 6 inches of the soil.

Now, it was already known from the experiment described on page 23 that in this soil when containing as much as 1 per cent of lime blueberry plants should either die or barely remain alive. As a matter of fact these limewater plants were making excellent growth. A careful examination of the contents of one of the pots was then made. The surface of the soil was covered with a hard gray crust of lime. Immediately underneath for a depth of about half an inch the soil was black and contained no live blueberry roots. There was a zone of the same black rootless soil along the wooden label that reached from the top to the bottom of the pot. In all other parts of the dark-brown peaty soil there was a dense mass of healthy roots, which reached down also into the open spaces among the broken crocks in the bottom of the pot. The lime appeared to have penetrated only into the superficial portions of the soil. A chemical test showed that the black rootless layer was densely impregnated with lime, while the brown peaty portion containing the growing roots still gave the acid reaction that was characteristic of the whole potful of soil before the limewater applications began.

Since all the water that the limeless root-bearing portion of the soil had received during the preceding seven months had come from the limewater applications, it was evident that the lime contained

in the limewater had been deposited in the upper layers of the soil. The following laboratory experiment confirmed this. A small quantity of the acid peaty soil used in growing blueberries was placed in a glass vessel and moistened. Then dilute limewater reddened by the addition of phenolphthalein, a substance giving a delicate color test for alkalies such as lime, was stirred into the soil and the mixture poured into an ordinary paper filter. The water came through the filter without a trace of red color, showed none after boiling, to drive off any possible carbonic acid, and when tested with ammonia and ammonium oxalate showed not a trace of lime. The precipitation of the lime had been complete and practically instantaneous. Only ten seconds had elapsed between the time when the limewater was added to the soil and the time when the liquid entirely free from lime began to drop through the filter.

In order to ascertain whether a large part of the lime in the limewater used on the plants may not have passed through the pots by running down the partially open channel along the label, some limewater was poured upon the surface of one of the pots. The excess water that soon began to drip through the bottom of the pot was tested for lime. It was found that while the limewater poured into the pot contained 0.1014 per cent of lime, the water that came through contained only 0.0046 per cent. In other words a pot of soil that for over seven months had been used essentially as a limewater filter still continued to extract over 95 per cent of the lime contained in the limewater that was passed through it, notwithstanding the fact that there was a partially open channel down one side of the pot. It is believed that had the soil been evenly compacted in the pot no lime whatever would have been able to pass through, but that all would have been precipitated in the uppermost layers.

While the experiment has no important bearing on the subject of blueberry culture it is of very great significance in its bearing on the method of applying lime to acid soils in ordinary agricultural practice. A surface application of lime would have no appreciable effect in neutralizing the acidity of a soil unless the soil was so sandy or gravelly or otherwise open that the rain water containing the dissolved lime could run down through it practically without obstruction. A surface dressing of lime would have little effect in neutralizing the acidity of an old meadow or pasture. To secure full action of the lime, as now generally recognized in the best agricultural practice, requires its intimate mixing with the soil, such as can be accomplished by thorough harrowing, especially after putting the lime beneath the surface with a drill. A full discussion of the physical reasons for the deposition of the lime in the upper layers of the soil, when not worked into it mechanically, is given in Bulletin 52 of the Bureau of Soils, published in 1908.

Among the experiments with blueberry seedlings in different soil mixtures started on December 22, 1908, was one in which six plants were set in glass pots in a peaty soil thoroughly intermixed with 1 per cent of carbonate of lime. The first difference that showed between these and unlimed plants in the same soil was the much feebler root growth of the limed plants. This was followed by an evident tendency toward feebler stem growth. The relative condition of the two cultures on April 13, 1909, is shown by photographs of representative plants reproduced as figures 7 and 8. The later progress of this

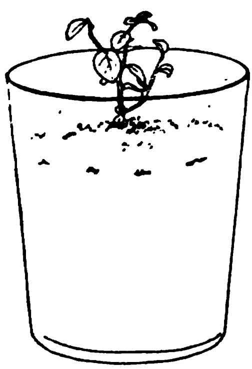


FIG. 7.—Blueberry seedling in peat mixture limed. (One-half natural size.)

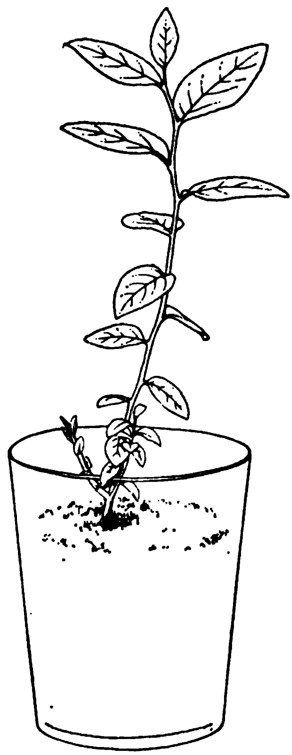


FIG. 8.—Blueberry seedling in peat mixture unlimed. (One-half natural size.)

experiment was interrupted, however, and its average results vitiated because the roots of some of the limed plants found their way through the holes in the bottom of the pots and obtained nourishment from the unlimed material in which the pots were plunged. Such plants made nearly as good growth as the unlimed plants. On November 27, 1909, there remained only one of the limed plants whose roots were all inside the pot. This plant was feeble and small, its stem being only 2½ inches high. Its inferiority to the unlimed plants was almost as conspicuous as that of the garden-soil plants described on page 17 and illustrated in figure 5.

(4) THE SWAMP BLUEBERRY DOES NOT THRIVE IN A HEAVY CLAY SOIL.

In its natural geographic distribution the blueberry shows an aversion to clay soils. Its favorite situations are swamps, sandy lands, or porous, often gravelly loams. When a blueberry plant grows upon a clay soil it is usually found that its finer feeding roots rest in a layer of half-rotted vegetable matter overlying the clay. Often in such situations the dense covering of interwoven rootlets and dark peatlike soil may be ripped from the surface in a layer little thicker than a door mat and of much the same texture. The roots of the blueberry do not penetrate freely into the underlying clay.

In greenhouse cultures the blueberry shows the same aversion to clay soils. Various series of blueberry seedlings were potted on May 26, 1908, in different soils in ordinary large drinking glasses. For one set of six plants a stiff clayey soil was used, such as is common in the neighborhood of Washington, D. C. The soil in the glass was mulched to the depth of nearly an inch with half-rotted leaves. In another six glasses were set six similar plants in a peat soil, the surface mulched in the same way as the others.

In other experiments with this clay soil in earthen pots, the growth of the plants had always been poor. The present experiment was no exception. But the feature of greatest interest was the behavior of the roots. Plate I, from photographs taken October 5, 1908, shows the root systems of typical plants in the two soils. In the clay soil almost no root development took place, and in the illustration no roots are visible. The interrupted black lines in the clay are tunnels made by larvæ or other animals. In the moist leaf mulch covering the clay, however, the plant developed its roots extensively. Some of the plants, probably because they were set too deeply in the clay when the potting was done, failed to send their roots up into the mulch, and such plants were much inferior in their growth to those that found the rotted leaves. In the other glass is shown the normal root growth of a blueberry in a soil suited to it.

(5) THE SWAMP BLUEBERRY DOES NOT THRIVE IN A THOROUGHLY DECOMPOSED LEAF MOLD, SUCH AS HAS A NEUTRAL REACTION.

It had been found in earlier experiments that certain soils composed in part of imperfectly rotted oak leaves were good for growing blueberries. On the supposition that the more thoroughly rotted this material was the better suited it would be for blueberry growing, a quantity of old leaf mold was secured for an experiment. The mold was black, mellow, and of fine texture. The mixed oak and maple leaves from which it was derived had been rotting for about five years, until all evidences of leaf structure had disappeared. It had the same appearance as the black vegetable mold that forms in rich woods where trilliums, spring beauty, and bloodroot delight to grow.

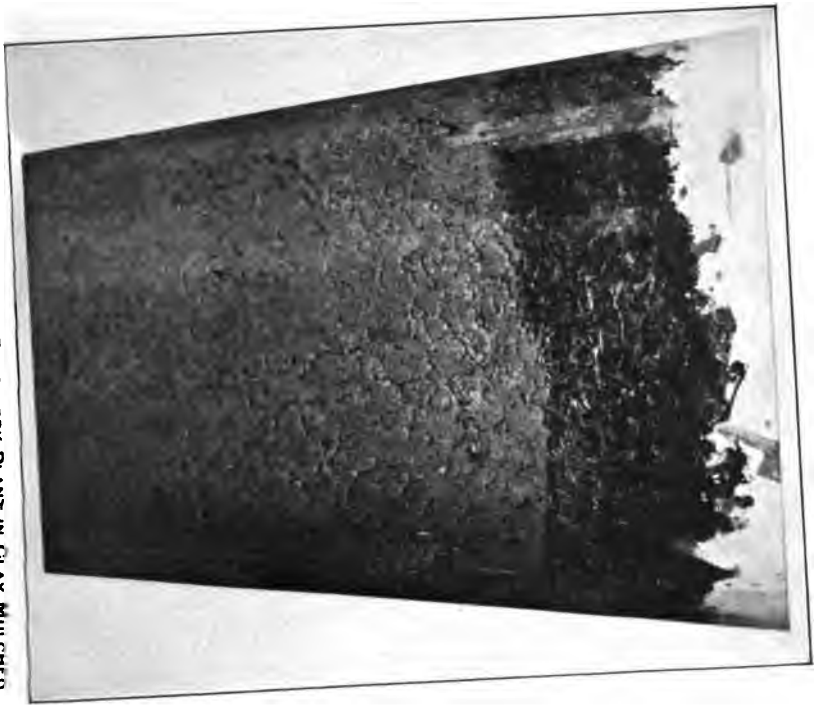


FIG. 1.—ROOT GROWTH OF A BLUEBERRY PLANT IN CLAY MULCHED WITH LEAVES. (Natural size.)

FIG. 2.—ROOT GROWTH OF A BLUEBERRY PLANT IN PEAT. (Natural size.)

On February 20, 1909, 25 blueberry seedlings were potted in 3-inch earthenware pots in a mixture consisting of eight parts by bulk of the leaf mold just described, one part of clean sand, and one part of clayey loam derived from rotted grass turf. Fifty other plants were potted in the same manner except that in place of the mold a peat was used known from earlier experiments to be well suited to blueberry growing. The plants were kept in the greenhouse until warm weather when they were placed outdoors. All were given the same treatment, a treatment favorable to good growth.

It had been expected that the plants in the leaf mold would show a vigorous growth, and it was hoped that the mold might prove even superior to the peat for blueberry soil mixtures. The experiment as it progressed, however, showed that such was not the case. The leaf mold proved to be not merely not a good soil for blueberries but an extremely poor one, as the following particulars will show.

When the plants were potted they averaged about 2½ inches in height. On May 29 the peat-soil plants had an average height of 7¼ inches, while the leaf-mold plants averaged 4¼ inches. At this time the herbage of the leaf-mold plants was decidedly purpled and yellowish, a coloration which they had taken on soon after they were potted and from which they never fully recovered. At the end of the season, after the leaves were shed, the peat-soil plants averaged 13¼ inches in height and the leaf-mold plants 7¾ inches. On November 29, 1909, five average plants from each lot were cut off at the surface of the ground and weighed. The weight of the stems from the leaf-mold plants was less than one-fifth that from the plants in the good blueberry soil.

When these plants were removed from their original seed bed to be transplanted to the 3-inch pots, such of the original soil as clung to their roots was not shaken off. It is believed that the leaf-mold plants fed in part on this original soil in making their new growth, and that without it they would have shown still less increase in height than they did. The peat-soil plants, moreover, were badly in need of repotting, even in early summer, and had they been placed in larger pots the difference in the growth of the plants in the two soils would have been much greater than it was.

That the influence of the leaf mold was directly deleterious and that the poor growth of the blueberry plants in it was not due to the lack of some element that might have been furnished by the addition of a small amount of the good blueberry soil is shown by certain intermediate experiments. Along with the cultures described above were carried two others in which the soil mixtures contained both peat and leaf mold. In the first, in which the proportion was peat 5, mold 3, sand 1, and loam 1, the average height of the plants on May 29

was 6 inches, and at the end of the season 12½ inches. In the second lot, in which the proportion was peat 3, mold 5, sand 1, and loam 1, the average height on May 29 was 4½ inches, and at the end of the season 11¾ inches. It will be observed that these two lots of plants are intermediate in their growth between the first two and that in all four lots the poverty of growth is roughly proportional to the amount of leaf mold used in the soil.

That the weak growth of the plants in leaf mold was not caused by a compacting of the soil and a lack of aeration, due to too small a proportion of sand in the mixture, is shown by still another lot of 25 plants which were potted in a soil mixture having the proportion of mold 6, sand 3, and loam 1. These plants averaged only 4 inches in height on May 29 and 6¼ inches at the end of the season. They grew even less, therefore, than the plants with only 1 part of sand and 8 parts of mold.

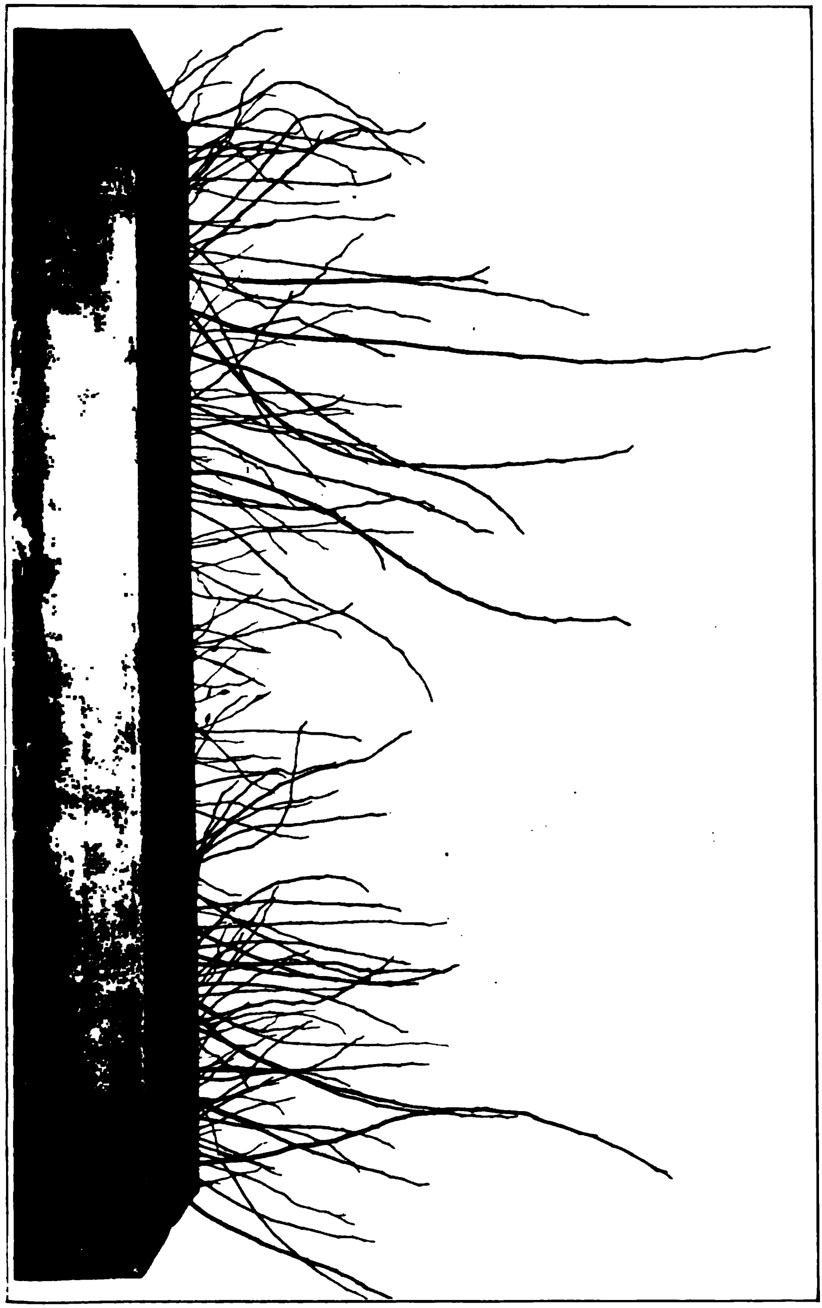
In Plate II, from a photograph made in the winter of 1909–10, is shown a flat divided into three parts and set on February 10, 1909, with blueberry seedlings of uniform size. The soil in the middle compartment is a mixture of leaf mold 8 parts, sand 1 part, and loam 1 part. In the compartment to the left the soil is in the proportion of kalmia peat 8, sand 1, and loam 1; and in the right-hand compartment, kalmia peat 4, leaf mold 4, sand 1, and loam 1. It will be observed that the greater the amount of leaf mold the poorer the growth of the blueberry plants.

The reason for the unexpected deleterious effect of leaf mold, as shown by these experiments, is given on page 29 and further discussed on page 35.

(6) THE SWAMP BLUEBERRY DOES NOT THRIVE IN SOILS HAVING A NEUTRAL OR ALKALINE REACTION, BUT FOR VIGOROUS GROWTH IT REQUIRES AN ACID SOIL.

The consideration of this statement requires first an understanding of the means used to determine whether a soil is acid or alkaline. The simplest means is the litmus test.

While one may become sufficiently expert in the use of the litmus test to form a fair judgment of the degree of alkalinity or acidity in a soil, an exact determination requires some different method. It was found that for the weak acids prevalent in the peat soils to the examination of which the present experiments led, the phenolphthalein test was the most satisfactory. If a few drops of phenolphthalein indicator be added to a solution, the solution, if alkaline, turns instantly pink, and if acid or neutral its color does not change. The application of this phenomenon to the determination of the degree of acidity of an acid solution is as follows: A definite amount of the solution, usually 100 cubic centimeters, is placed in a beaker, a few drops of an alcoholic solution of phenol-



BLUEBERRY SEEDLINGS IN PEAT AND LEAF MOLD.

(One-sixth natural size.)

phthalein are added, and into this is stirred drop by drop from a graduated glass tube provided with a stopcock, known as a burette, a measured amount of some alkaline solution of known strength, commonly a one-twentieth normal solution, as it is known to chemists, of sodium hydrate. When a sufficient amount of the sodium-hydrate solution has been dropped into the beaker, the acidity of the acid solution becomes neutralized and it turns pink. A reading is made on the burette showing the exact amount of the sodium-hydrate solution used in effecting the neutralization. From this reading is computed the degree of acidity expressed in fractions of a normal acid solution. Now 100 c. c. of a normal acid solution would require for its neutralization 100 c. c. of a normal solution of sodium hydrate, or 2,000 c. c. of a one-twentieth or 0.05 normal solution. In a test of one of the acid nutrient solutions used in the blueberry cultures, 18 c. c. of a 0.05 normal solution was required to neutralize the acidity of 100 c. c. of the acid solution. Since 18 c. c. of a 0.05 normal solution is the equivalent of one-twentieth that amount, or 0.9 c. c. of a normal solution, the degree of acidity of this acid solution is 0.009 normal. It requires an equal amount of a 0.009 normal alkaline solution to neutralize it.

In applying this phenolphthalein test to soils the same scale is used. A soil is regarded as having normal acidity when the acid existing in a gram of the soil if dissolved in 1 c. c. of water gives a normal acid solution. If a soil were described as having an acidity of 0.02 normal, it would mean that the extract of 100 grams of it in 100 c. c. of water would be a 0.02 normal acid solution; that is, that 100 c. c. of the solution would contain 2 c. c. of a normal acid solution.

The method of extraction followed for all the soil acidity tests given in this paper is as follows: The soil is first air dried at an ordinary room temperature. Ten grams are then weighed out, shaken thoroughly with 200 c. c. of hot water, and allowed to stand over night. In the morning 100 c. c. is filtered off and boiled to drive away any carbon dioxid present. The solution is then titrated with a 0.05 normal solution of sodium hydrate, using phenolphthalein as an indicator. All the tests were made by Mr. J. F. Breazeale, of the Bureau of Chemistry, to whom the writer is greatly indebted for many courtesies and suggestions on the chemical side of the experiments.

The expression "normal solution" used in this paper, it must be understood, is the normal solution of chemists, not of surgeons. Surgeons use the expression "normal salt solution" to describe a certain weak solution of common salt in water which has the same osmotic pressure as the blood. A normal solution in chemistry is a solution of certain fixed strength, or concentration, based on the molecular weight of the substance under consideration. Normal solu-

tions of the various acids have the same degree of acidity. Normal solutions of alkaline substances are equal to each other in alkalinity. A measured amount of a normal solution of an acid will exactly neutralize an equal amount of a normal solution of an alkaline substance.

In considering the degree of acidity from the standpoint of the sense of taste it is convenient to remember that the juice of an ordinary lemon is very nearly a normal solution of citric acid. The juice of the lemon contains usually from 6 to 7 per cent of citric acid. A normal solution of citric acid is 6.4 per cent. When the juice of a lemon is diluted to about ten times its original bulk, as in a large drinking glass, one has approximately a 0.1 normal acid solution. When diluted to 100 times, making about a 0.01 normal solution, there remains only a faint taste of acidity. The acidity of water after standing long in contact with peat in a barrel sometimes reached 0.005 normal. Bog water, or peat water, is sometimes appreciably acid to the taste.

Returning now to a consideration of the statement that the swamp blueberry does not thrive in a neutral or alkaline soil an experiment in this direction may first be cited. The experiment was made with twelve small glass pots, each containing a blueberry seedling. The soil in the pots was a clean river sand. The plants had been in these pots for eight weeks, watered with tap water. The amount of nourishment they had received during this time was therefore very small, especially since, when transplanted into the pots, all the soil of the original seed bed had been carefully removed from the roots. Nevertheless during these eight weeks all the plants had made extensive, even luxuriant, root growth. The tops, however, had made no growth. There had been complete stagnation or withering of the youngest leaf rudiments, and the mature leaves became and remained deeply purpled.

Beginning on February 17, 1909, eight weeks after the plants had been potted in the sand, as already stated, five of the pots were watered with an acid nutrient solution made up, in accordance with the advice of Mr. Karl F. Kellerman, of the Bureau of Plant Industry, as follows:

Potassium nitrate (KNO_3)	1.0 gram.
Magnesium sulphate ($MgSO_4$)	0.4 gram.
Calcium sulphate ($CaSO_4$)	0.5 gram.
Calcium monophosphate ($CaH_4P_2O_8$)	0.5 gram.
Sodium chlorid ($NaCl$)	0.5 gram.
Ferric chlorid ($FeCl_3$)	Trace.
Water	1,000 c.c.

This solution gave an acidity test of 0.012 normal.

Five other plants from the same twelve were watered with an alkaline nutritive solution of the following composition:

Potassium nitrate (KNO_3)	1.0 gram.
Magnesium sulphate ($MgSO_4$)	0.4 gram.
Calcium sulphate ($CaSO_4$)	0.5 gram.
Potassium diphosphate (KH_2PO_4)	0.4 gram.
Sodium chlorid ($NaCl$)	0.5 gram.
Ferric chlorid ($FeCl_3$)	Trace.
Water	1,000 c. c.

By the addition of a sufficient quantity of sodium hydrate the reaction of this solution was made alkaline to the degree of 0.006 normal.

Two of the twelve plants were left as checks, being still watered with tap water.

On March 25, thirty-six days after the watering began, the five plants fed with the acid nutritive solution were restored to a nearly normal green color, and all had begun to put out healthy new growth. The two check plants watered with tap water were still red-purple and stagnant. Of the five plants watered with the alkaline nutrient solution, three were stagnant and somewhat purplish, one was dying, and one was dead.

Figures 9 and 10, from photographs taken on April 15, 1909, show a typical stagnant plant that had been watered with the alkaline solution, and a typical plant watered with the acid solution which had begun to make new growth from the summit of the old stem and was pushing out a vigorous new shoot from the base. The experiment was terminated not long afterwards, but there was every prospect that had it been continued the acid-fed plants would soon have made growth comparable with that shown in figure 8 (p. 23).

Looking toward the acidity or alkalinity of the other cultures thus far cited, it may be stated that the rich garden soil described on page 14, which was so remarkably deleterious to blueberry seedlings, was alkaline. The rose cuttings and the alfalfa, which grew so well in that mixture, much prefer a somewhat alkaline soil. Indeed, alfalfa can not be grown with any degree of success in any soil except one with an alkaline reaction. When grown in the humid eastern United States alfalfa is rarely successful, except on calcareous soils, unless the natural acidity of the soil has been neutralized by suitable applications of lime.

The limed soil, deleterious to blueberry plants, described on page 23, gave a neutral reaction with phenolphthalein.

The heavy clay soil described on page 24, in which blueberry plants made very little growth, was neutral.

The thoroughly decomposed leaf mold described on pages 24 to 26, which was shown by experiment to be markedly deleterious to the

blueberry, was distinctly alkaline. A chemical analysis of this mold showed that it contained 2.86 per cent of calcium oxid.

The good blueberry soils in all the experiments were acid, the acidity at times of active growth varying from 0.025 normal down to 0.005 normal.

It is of interest and suggestive of utility in indicating the acid or nonacid character of soils to record that in the case of the alkaline leaf mold described on page 24 the surface of the soil in all the pots became covered in a few months with a growth of a small moss identified through the courtesy of Mrs. N. L. Britton as *Physcomitrium immersum*. On the surface of acid kalmia-peat soils the characteristic green growth consisted of microscopic algæ, accompanied often by fern prothallia and other mosses, but never Physcomitrium.

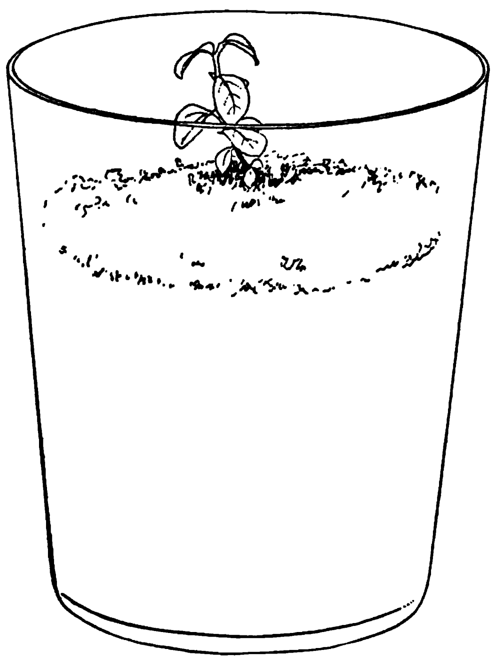


FIG. 9.—Blueberry seedling fed with alkaline nutrient solution. (Natural size.)

The natural distribution of blueberries and their relatives indicates their close adherence to acid soils. They occur in abundance throughout the sandy Coastal Plain of the Atlantic seaboard. They occur generally through the cool humid hill lands of New England. They occur in sandy pine barrens and peat bogs throughout the eastern United States. They are absent, on the contrary, from limestone soils, rich bottom lands, and rich woods, where the soils are neutral or alkaline. In the lower elevations of the whole subarid West, where acid soils are almost unknown, these plants do not occur. Within reach of the fogs and heavy rainfall of the Pacific coast or on the higher mountains of the interior, where conditions favor the development of acid soils, blueberries occur again in characteristic abundance.

From an examination of the reports of those who have attempted at the agricultural experiment stations to domesticate and improve the blueberry, it is evident in the light of the present experiments that the primary reason for these failures was that they did not recog-

nize soil acidity as a fundamental requirement of these plants. It was perhaps natural to give the blueberry the same garden culture that when applied to other bush fruits has resulted in their distinct improvement. But the ordinary garden operations tend to make even an acid soil neutral or alkaline, and in such a soil the blueberry does not thrive.

The death and decay of blueberry roots, with which the injurious effect of alkaline soils is associated, are discussed on pages 64 and 65.

(7) THE FAVORITE TYPE OF ACID SOIL FOR THE SWAMP BLUEBERRY IS PEAT.

Although the swamp blueberry sometimes grows on upland soils its typical habitat, as its name implies, is in swamps or bogs. The cranberry, it is well known, is cultivated almost exclusively in bogs. In clearing bog land preparatory to the planting of cranberries one of the necessary precautions is to remove all roots of the swamp blueberry. If the roots are allowed to remain in the ground, they send up vigorous shoots, and these, unless pulled, develop into robust plants which occupy the ground to the great injury of the cranberries. Large, healthy, and productive bushes of the swamp blueberry are frequent, almost characteristic, inhabitants of the uncultivated borders of cranberry bogs.

FIG. 10.—Blueberry seedling fed with acid nutrient solution. (Natural size.)

Peat bogs, in the conception of geologists, are incipient coal beds. The transformation of peat into coal occupies very long periods, perhaps some millions of years. Peat is made up chiefly of vegetable matter, the dead leaves, stems, and roots, of bog plants which are only partly decayed. Their full decay is prevented primarily by the presence of water, which keeps away the air. The bacteria,

fungi, and other organisms by which ordinary decomposition progresses can not live under this condition and decay is suspended. The acids developed by this vegetable matter in the early stages of its decomposition are also destructive to some of the organisms of decay, especially bacteria. These acids act therefore as preservatives and greatly assist in preventing decomposition. So effective are these conditions of acidity and lack of oxygen, assisted in northern latitudes by low temperature, which is also inimical to the organisms of decay, that bogs sometimes preserve for thousands of years the most delicate structures of ferns and mosses.

Tests have been made of the acidity of typical peat bogs in New England where swamp blueberries are growing. These peats were always found to be acid and the degree of acidity was within the range found satisfactory for blueberry plants in pot cultures.

The reason why peat is a particularly satisfactory type of acid soil for blueberries is, apparently, because the acidity of peat is of a mild type, yet continually maintained.

Not all peats are acid. About the larger alkaline (but not destructively alkaline) springs of our southwestern desert region are deep deposits of rather well-decayed vegetable matter that must be classed as peat. The characteristic vegetation growing on these peats is tule (*Scirpus occidentalis* and *S. olneyi*). The water of one of the great tule swamps of the West (Lower Klamath Lake in southern Oregon), which contains thick beds of peat formed chiefly from *Scirpus occidentalis*, has been examined recently by Mr. J. F. Breazeale, at the request of Mr. C. S. Scofield. It was found to contain sodium carbonate, and the peat gave a distinctly alkaline reaction.

The peat formed about marl ponds in the eastern United States is also, in all probability, alkaline unless formed at a sufficient distance from the lime-laden water to be beyond the reach of its acid-neutralizing influence.

Such alkaline peats, while not actually tried, are believed from other experiments to be quite useless for growing blueberries. Certain it is that neither blueberries nor any of their immediate relatives are found on these soils in a wild state. In the eastern United States, however, such alkaline peats are comparatively rare, and the use of the word "peat" conveys ordinarily the idea of acidity. All the soils used by gardeners under the name of peat are acid.

(8) PEAT SUITABLE FOR THE SWAMP BLUEBERRY MAY BE FOUND EITHER IN BOGS OR ON THE SURFACE OF THE GROUND IN SANDY OAK OR PINE WOODS.

In the vicinity of Washington deposits of bog peat are few and of limited extent, and the peat is thin. As a matter of fact no bog peat of local origin is used by the gardeners and florists of Washington. For growing orchids, ferns, azaleas, and other peat-loving plants, either peat shipped from New Jersey is used or a local product some-

times known as "Maryland peat." This material is not a bog peat at all, and since it is of very great interest in connection with these blueberry experiments, for it was the principal ingredient in a majority of the successful soil mixtures used, it is desirable that the reader have a comprehensive idea of its character.

Maryland peat, as brought to the greenhouses of the United States Department of Agriculture, consists of dark-brown turfs or mats, 2 to 4 inches thick, made up of partially decomposed leaves interlaced with fine roots. It is found in thickets of the American laurel (*Kalmia latifolia*) where the leaves of this shrub, usually mixed with those of various species of oak, have lodged year after year and the accumulated layers have become partly decayed.

The nature of the deposit may be easily comprehended by means of the accompanying illustrations. The photographs from which the illustrations were made were secured through the courtesy and skill of Mr. G. N. Collins, of the Bureau of Plant Industry. The photographs were made in the month of April, 1908, in a laurel thicket at Lanham, Md. After one photograph was made, the layer of leaves represented by it was removed and another photograph was taken showing the layer immediately underneath.

In Plate III, figure 1, is shown the top layer of the leaf deposit as it appeared in April, 1908, consisting of oak leaves of various species which fell to the ground in the autumn of 1907. The next underlying layer is shown in Plate III, figure 2. The laurel leaves here shown are those that fell in the summer of 1907. Laurel being an evergreen, its leaves are not shed in the autumn like those of the oaks. They remain on the bush until the new leaves of the following spring are fully developed and then the old leaves begin to fall. It is this circumstance of the fall of the oak and laurel leaves at different periods of the year that enables one to recognize the different layers and know their exact age. The third layer, shown in Plate IV, figure 1, consists of oak leaves of the autumn of 1906. This layer was moist and decomposition was well started. The presence of fungous growth is evident, as is also the excrement of various small animals. Myriapods, or thousand-legged worms, and the larvæ of insects must play a very important part under some conditions in hastening the decomposition of leaves. The fourth layer, Plate IV, figure 2, consisting of laurel leaves shed in the summer of 1906, is in about the same condition as the preceding layer. In the fifth layer, Plate V, figure 1, are shown the leaves of 1905, but the layer of oak leaves is not readily separable from the laurel. The rotted leaves crumble readily and decomposition has so far progressed that a few oak rootlets are found spread out between the flattened leaves. Plate V, figure 2, shows the rotted leaf layers of 1904 interlaced with the rootlets of laurel and oak. It is this root-bearing layer, 2 inches or more in thickness, of which

Maryland peat is composed. The lower portions of it reach a somewhat greater degree of decomposition than is here shown.

In a rich woods of the trillium-producing type, such as a fertile sugar-maple forest, one may observe that the leaves in rotting seldom retain their form longer than two years and that the line of demarcation between the thin leaf litter of the forest and the underlying woods mold is sharp and clear.

In the sugar-maple woods the decomposition of the leaves is rapid. In the Maryland or kalmia peat, as it may be called with more exactness, the decomposition is slow. The cause of this difference in the rate of decomposition is the difference of acidity in the two cases, and this in turn is dependent on the nature of the leaves and of the underlying soil, particularly whether the soil is acid or alkaline. A slight alkalinity in a soil greatly favors the decomposition of the leaves overlying it. An acidity as strong as that shown to occur in newly fallen oak leaves (see p. 62) can not help having a pronounced effect in maintaining the acidity of the lower leaf layers; for it must be remembered that these acids are soluble in rain water, and are therefore continually leaching down from the upper through the lower layers of rotting leaves.

These upland leaf deposits, in which decomposition is retarded for many years, the writer regards as essentially peat, and to distinguish them from bog peats he would call them upland peats. An upland peat may be described as a nonpaludose deposit of organic matter, chiefly leaves, in a condition of suspended and imperfect decomposition and still showing its original leaf structure, the suspension of decomposition being due to the development and maintenance of an acid condition which is inimical to the growth of the micro-organisms of decay.

The use of the name "leaf mold," sometimes applied to this upland peat, should be restricted to the advanced stages in the decomposition of leaves, in which leaf structure has disappeared. True leaf mold, furthermore, is neutral or alkaline, so far as tested.

When kalmia peat is to be used for growing blueberries it should be piled and rotted for several months. An experience which emphasizes the need of this treatment is given on page 60. If stacked as soon as it is dug it usually retains sufficient moisture to carry the rotting forward, even if the stack is under cover.

Kalmia peat has proved to be a highly successful soil for growing blueberries. It has been tried both pure and in many mixtures, as will be described in the paragraphs beginning on page 51.

An upland peat formed of the leaves of scrub pine (*Pinus virginiana*) has also been tried for blueberry seedlings. They grow well in it.

Oak leaves, it is believed, rotted for one or two years would make a good blueberry soil. In the Arlington National Cemetery is a ravine

FIG. 1.—FORMATION OF KALMIA PEAT, TOP LAYER.
Oak leaves of the preceding autumn. (Natural size.)

FIG. 2.—FORMATION OF KALMIA PEAT, SECOND LAYER.
Kalmia leaves of the preceding summer. (Natural size.)

in which large quantities of leaves, chiefly oak, have been dumped for many years. Samples taken there in late November, 1909, show an acidity in the case of freshly fallen leaves of 0.4 normal; in leaves apparently 1 year old, 0.006; and in leaves about 2 years old, 0.002.

A condition of great interest was found in one of these piles of leaf mold which was several years old. It was mellow and black, and the evidence of leaf structure had disappeared. When submitted to the phenolphthalein test it proved to be alkaline, and upon chemical examination it was found to contain 3.55 per cent of lime (CaO). In this case decomposition had progressed so far, it is suggested, that the lime in the leaves, remaining constant in amount and probably having been changed to a more soluble state, had neutralized the remaining acidity. The material, then becoming alkaline, had proceeded to decompose with greater rapidity, until a real mold had been formed.

The condition here observed is doubtless the same as that which occurs in the drained bog, or so-called "muck," lands of Michigan. When first plowed they will grow only certain acid-resistant crops, such as buckwheat or potatoes, but later, as their acidity disappears, they come to attain a very high degree of fertility. It is probably a phenomenon of similar character which is taking place in the drained swamp lands of the lower Sacramento River in California, where the soil, which is already in a state of remarkable fertility, is becoming increasingly alkaline.

Here allusion may be made to another phenomenon, that of the occurrence of the swamp blueberry and certain other plants, such as the purple lady's-slipper (*Cypripedium acaule*) and the swamp honeysuckle (*Azalea nudiflora*), in two kinds of situations—one a peat bog, the other a sandy, well-drained, and often dry upland. The favorite explanation of this phenomenon among botanists is that these plants are naturally adapted to the drier situation and that in the bog they find a situation of "physiological dryness," or vice versa. While the existence of physiological dryness in peat bogs is not questioned, the explanation that a bog plant finds an upland situation congenial because it is dry certainly will not answer for the blueberry. Its occurrence in these two habitats is dependent on the acidity of both situations. These experiments have shown that no amount of dryness will make a blueberry flourish in an upland soil if that soil is not acid.

(9) FOR ACTIVE GROWTH THE SWAMP BLUEBERRY REQUIRES A WELL-AERATED SOIL. CONVERSELY, THE SWAMP BLUEBERRY DOES NOT CONTINUE IN ACTIVE GROWTH IN A SOIL SATURATED WITH WATER.

In its natural distribution the swamp blueberry does not grow in the lower, wetter type of bog. In a typical leatherleaf (*Chamaedaphne calyculata*) bog, for example, the swamp blueberry is found

FIG. 1.—FORMATION OF KALMIA PEAT, FIFTH LAYER.

Mixed oak and kalmia leaves 3 years old. A few live rootlets of oak are shown. (Natural si

FIG. 2.—FORMATION OF KALMIA PEAT, SIXTH LAYER.

Mixed oak and kalmia leaves 4 years or more old interlaced with live rootlets of oak and kal
(Natural size.)

remaining in the soil after this treatment is known as the moisture equivalent of that soil. A test of kalmia peat made by Dr. Lyman J. Briggs, of the Bureau of Plant Industry, the originator of this method of measurement, showed a moisture equivalent of 142 per cent, as compared with about 30 per cent for clay, 18 per cent for loam, and 2 to 4 per cent for sand.

From what has been said it is evident that fibrous kalmia peat has physical characteristics that allow the soil to be amply aerated, while at the same time holding abundant moisture for the supporting of plant growth.

In this connection reference may be made to the influence of earthworms on potted blueberry plants. Late in the winter of 1908–9 it was noted that among the blueberry seedlings of 1907, which had been brought into the greenhouse, were several in which the growth was feeble, although others of the same lot were growing vigorously. It was noted also that the soil in the pots in which the feeble plants were growing contained earthworms, as evidenced by the excrement or casts deposited by them on the surface. The worms themselves were easily found by knocking the earth ball out of the pot, and the soil was seen to have been thoroughly worked over by the worms.

It was supposed at first that the soil (a mixture of peat 8, sand 1, loam 1) in the process of digestion to which it had been subjected in passing through the alimentary canal of the earthworms might have become alkaline and for this reason injurious to the blueberry plants. When tested with phenolphthalein, however, the soil in the pots containing earthworms and feeble plants was found to be of the same acidity as that in the pots containing no earthworms and with vigorously growing plants. Furthermore the fresh casts themselves were of a similar degree of acidity.

The texture of the soil, however, in the pots containing worms was very different from that in the others. It was plastic, very fine grained, almost clayey, the organic portion having been very finely ground evidently in passing through the gizzard and other digestive apparatus of the earthworms. The aeration of the soil in this condition must have been far poorer than in the coarser soil containing a large amount of leaf fragments not worked over by worms, and it may be that the difference in growth of the blueberry plants was due to the difference in aeration. It is not by any means certain, however, that the plants in the pots containing earthworms may not have been injured directly through the eating of their rootlets by the worms.

(12) AERATION CONDITIONS SATISFACTORY FOR THE SWAMP BLUEBERRY ARE FOUND IN MASSES OF LIVE, MOIST, BUT NOT SUBMERGED SPHAGNUM.

In some swamps the water level remains permanently above the general surface of the ground. When the swamp blueberry occurs

in such situations it grows on hummocks the summits of which stand above the water during the growing season. Unless the water level is extremely variable or the ground is densely shaded, these hummocks are usually covered with a cushion of live sphagnum moss. It is a peculiarity of this moss that it absorbs water with great avidity; indeed, sphagnum is one of the most absorbent substances known. If one end of a nearly dry branch of sphagnum is brought into contact with a little water, the whole branch becomes wet almost instantly. The water rushes along with marvelous rapidity through the cells of the plant and especially through the interstices between the minute overlapping leaves. The white air spaces between the half dry leaves flash out of existence one after the other like candle flames in a gust of wind. The same ability to absorb water is characteristic of masses of this plant. If the lower part of a cushion of sphagnum is in contact with free water the fluid is conveyed from stem to branch and from plant to plant in sufficient amount to render the whole mass as wet as a sponge. When one squeezes a handful of such moss taken perhaps a foot or more above the source of moisture the water runs out in streams. A sample of live sphagnum with less moisture than usual but still with enough to maintain itself in a growing condition was found to contain 991 per cent of water, computed on the dry weight of the sphagnum, while saturated live sphagnum carried 4,005 per cent of water. On the basis of its dry weight, therefore, sphagnum contains about ten times as much water as peat, which itself contains about six times as much as ordinary loam and about thirty-five times as much as sand.

The innumerable extracapillary air spaces between the branches of sphagnum plants and between the plants themselves furnish good aeration, even when the individual branches are saturated with water. When the moisture is less the aeration is still better. The cushion of sphagnum on a hummock tends to build itself up by the gradual process of growth and decay to the maximum height to which it can convey the large amount of water required for its growth, and an increasing degree of aeration is found from the water line upward.

If the sphagnum cushion on a blueberry hummock is examined the whole mass will be found interlaced with the minute rootlets of the blueberry, far above the level of the underlying soil. The conditions of permanent moisture and thorough aeration found in these sphagnum cushions seem to be almost ideal for the development of blueberry roots.

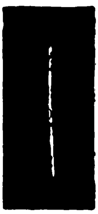
It must not be assumed that the vigorous growth of blueberry roots in sphagnum is due to any high nutritive quality of the sphagnum itself. Such a conclusion would be erroneous. When set out in sphagnum and watered with tap water, blueberry plants remain healthy and develop a very large root system, but the stems do not

grow as luxuriantly as when the plants are in a peat soil. From experiments with the growing of blueberries in sand watered with peat water it is known that such water furnishes the food materials necessary for vigorous growth. It is reasonable to conclude, therefore, that the chief nourishment of a blueberry plant growing on a pure sphagnum hummock comes from the bog water sucked up by the sphagnum and not from the sphagnum itself.

PECULIARITIES OF NUTRITION.

(13) THE SWAMP BLUEBERRY IS DEVOID OF ROOT HAIRS, THE MINUTE ORGANS THROUGH WHICH THE ORDINARY PLANTS OF AGRICULTURE ABSORB THEIR MOISTURE AND FOOD.

The structure of the rootlets of ordinary agricultural plants may be understood by reference to figures 11 to 13, which illustrate these organs as they occur in a wheat seedling germinated between layers of moist blotting paper. Attention is directed particularly to the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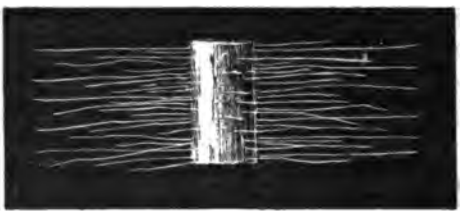

12.


13.

FIG. 11.—Root of a wheat plant, showing the root hairs. (Natural size.)
FIG. 12.—Portion of a wheat root, with root hairs. (Enlarged 10 diameters.)
FIG. 13.—Tip of the root hair of a wheat plant. (Enlarged 1,000 diameters.)

root hairs. It will be observed that the wall of the root hair is very thin, appearing in optical section as a mere line with barely measurable thickness, even when highly magnified. Furthermore, the surface area of the root hairs is many times greater than that of the root itself. The chief function of these root hairs is to absorb for the use of the plant the soil moisture and the plant-food materials dissolved in it, a function which the root hairs are enabled to perform with great efficiency because of the two characteristics just mentioned—their large surface area and the thinness of their walls.

The rootlets of the blueberry are remarkable in having no root hairs whatever, as may be seen by reference to figures 14 to 16. The walls of the superficial, or epidermal, cells of the rootlets are thick, measuring 0.00005 to 0.0001 of an inch (1.3 to 2.5 μ), while the walls of the root hairs of wheat are one-fourth to one-sixth as thick, so thin, in fact, that they could be measured only with difficulty

even when enlarged 5,900 diameters. Notwithstanding the fact, therefore, that the blueberry roots are fine and numerous, their actual absorptive capacity would appear to be small, in consequence of the absence of root hairs.

FIG. 14.—Root of a blueberry plant. (Natural size.)

It is found by a computation that a section of a blueberry rootlet having no root hairs presents about one-tenth the absorptive surface of an equal area of a wheat rootlet bearing root hairs, and the thickness of the surface membranes in the wheat is certainly not more than a quarter that in the blueberry. Furthermore, the blueberry rootlet grows only about 0.04 inch (1 mm.) a day under favorable conditions, while the wheat rootlet often grows twenty times as fast. In all this provision for rapid food absorption in the one plant and retarded absorption in the other we find a reason for

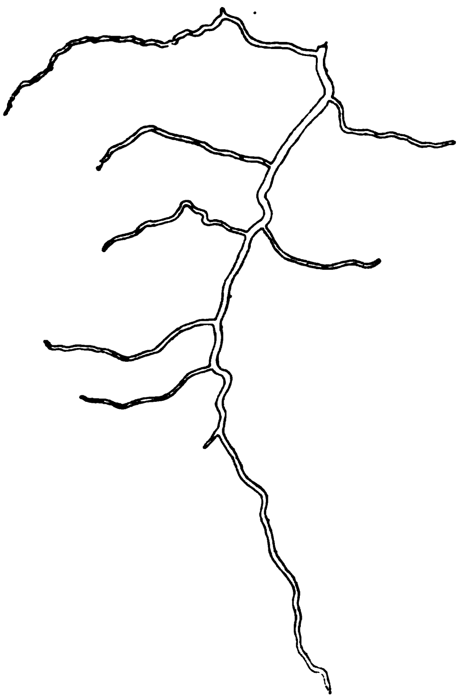


FIG. 15.—Root of a blueberry plant. (Enlarged 10 diameters.)

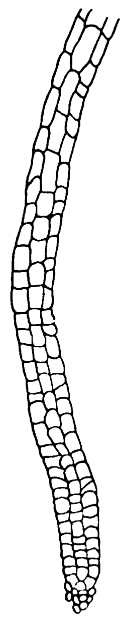


FIG. 16.—Blueberry rootlet. (Enlarged 100 diameters.)

the comparatively very slow rate of stem growth that characterizes the blueberry plant. The importance of slow root absorption and the danger to which these plants would be subjected if their roots absorbed water rapidly are discussed on page 50.

The young rootlets of the blueberry before they branch are exceedingly slender, varying from 0.002 to 0.003 of an inch (50 to 75 μ) in diameter. This makes them very susceptible to actual drying and they are easily killed by it. This characteristic has an important bearing on the treatment of these plants when in pots. The matter is discussed on pages 65 to 67.

(14) THE ROOTLETS OF HEALTHY PLANTS OF THE SWAMP BLUEBERRY ARE INHABITED BY A FUNGUS, OF THE SORT KNOWN TECHNICALLY AS AN ENDOTROPHIC MYCORRHIZA.[a]

As already stated, the ultimate rootlets of the blueberry are very fine, their diameter varying from 0.002 to 0.003 of an inch (50 to 75 μ). In rootlets of the smaller size about three rows of epidermal cells are visible in a lateral view, in the larger rootlets about five rows. In a newly grown rootlet not contaminated with soil particles these epidermal cells, and, indeed, all the underlying cells as well, are as transparent as glass, and were it not for the difficulties due to the refraction of light the examination of the contents of the cells would not be difficult. As a matter of fact the study of the contents of the live cells is difficult, their intelligent examination requiring the use of an oil immersion objective and microscopic enlargements of 1,000 to 1,500 diameters. The darkened window installation for a microscope, devised by Dr. N. A. Cobb, of the Bureau of Plant Industry, and used in his laboratory, has been found almost indispensable in this work.

Clean rootlets may be procured readily from active blueberry plants in the open spaces between half-rotted leaf blades, in clean sand, in live sphagnum, or at the outer surface of the ball of soil in earthen pots. Rootlets taken from live sphagnum are especially clean. They are conveniently studied when simply placed in water on a microscope slide under a thin cover glass held in place by a ring of paraffin.

Ordinarily the only thing visible in one of the live epidermal cells is the minute cell nucleus lying close to the cell wall. The protoplasmic membrane lining the cell is very thin and is invisible except where it is thickened to envelop the nucleus. The remainder of the cell is filled with the colorless cell sap. An examination with medium enlargements will show some of the cells faintly clouded in appearance. A higher power, such as is afforded by a 2-mm. oil immersion objective and a 12-mm. eyepiece, with proper illumination, will resolve the cloudiness into a mass of fungous threads, or hyphæ. These may be few, making only two or three irregular turns about the interior of the cell, as occasionally found, or they may be more numerous, even occupying the whole sap space, as shown in figure 17, in a dense knot

[a] The spelling *mycorhiza* is also in good standing and is used in many German, English, and American botanical works.

of interwoven and irregular snakelike coils. These hyphæ are about 0.00006 to 0.00012 of an inch (1.5 to 3 μ) in diameter.

On the outer surface of the cells containing these fungous threads others of similar or a little greater thickness may be observed. Sometimes they are transparent and their detection requires the same high power of the microscope as do those in the interior of the cells. Sometimes, however, these exterior threads have a pale-brown color and are then readily seen. Their surface is smooth, devoid of markings of any kind. Ordinarily the thread wanders loosely along the surface of the root giving off an occasional branch and having an occasional septum. Sometimes the threads and their branches may form an open network about the rootlet, but they never form a dense sheath of hyphæ such as is characteristic of the mycorrhiza of the oak.

The connection between the external and the internal hyphæ is not easy to see at a single observation, for the passage of the hyphæ through the cell wall is rarely caught in optical section, and even then a clear observation is usually rendered difficult because of refraction. A very clear case, however, was observed in a rootlet of laurel (*Kalmia latifolia*), a shrub which has a mycorrhizal fungus similar to that of the blueberry. A drawing of that specimen is shown in figure 18.

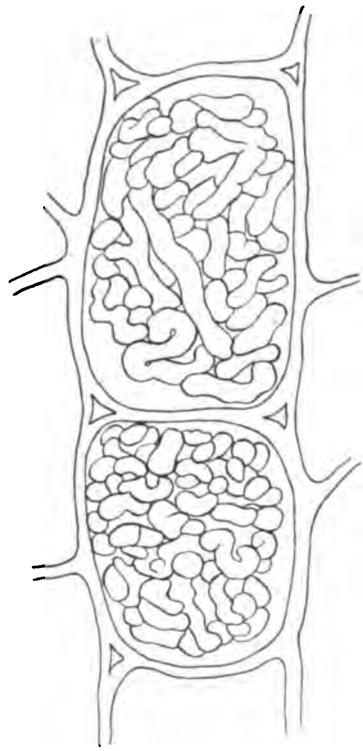


FIG. 17.—Mycorrhizal fungus of a blueberry plant densely crowded in two epidermal cells of the root. (Enlarged about 1,200 diameters.)

The passage of the fungus through the cell wall may frequently be observed in the blueberry by first focusing on the external hypha at a point where it appears to have a lateral hump or a very short branch, and then focusing slowly downward. In this way one passes from the external to the internal part of the fungus, having had some portion of the intervening hypha continuously in view. The hypha always appears much constricted at the point where it goes through the cell wall.

This fungus is of the type named by Frank in 1887 an endotrophic mycorrhiza to distinguish it from an ectotrophic mycorrhiza, such

as occurs on the roots of oaks. In the latter type of mycorrhiza the hyphæ of the fungus form a dense sheath around the rootlet, completely shutting it off from direct contact with the surrounding soil. The loose hyphæ on the outside of the sheath resemble root hairs and it is supposed to be a part of their function to absorb soil moisture and transmit it to the oak rootlet just as root hairs do.

It has not yet been possible, for want of time, to study the life history of this mycorrhizal fungus of the blueberry. There is, however, a clew to its identity in the work of Miss Charlotte Ternetz, Ph. D., described on page 49.

The experiments thus far made do not warrant a supposition that any good peat soil requires inoculation with the mycorrhizal fungus before blueberry plants will grow well in it. The fungus appears either to be already in the soil or to accompany the seeds when they are sown in it.

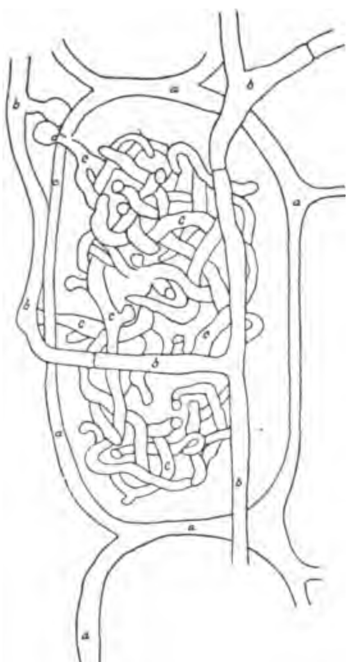


FIG. 18.—Mycorrhizal fungus of *Kalmia latifolia* in an epidermal cell of the root: *a*, Cell walls; *b*, external hyphæ of the mycorrhizal fungus; *c*, internal hyphæ; *d*, point of penetration of the cell wall by the mycorrhizal fungus. (Enlarged about 1,000 diameters.)

(15) THE MYCORRHIZAL FUNGUS OF THE SWAMP BLUEBERRY APPEARS TO HAVE NO INJURIOUS EFFECT, BUT RATHER A BENEFICIAL EFFECT, UPON THE BLUEBERRY PLANT.

The epidermal cells in which the mycorrhizal fungus occurs are not swollen nor distorted, nor do their contents collapse or show any of the other effects usually produced by pathological fungi. They appear to differ in no respect from other epidermal cells of the blueberry rootlets. In rapidly growing rootlets the fungus seems not to be able to keep pace with the rootlet itself and may not occur for a considerable distance back from the growing tip. The fungus-filled cells ordinarily are most numerous on certain small, short, and crooked lateral rootlets the growth of which is slow. When root growth of a vigorous plant is retarded or becomes even stagnated, the fungus may invade the epidermal cells to the very apex. Sometimes half the cells in such a rootlet are gorged with fungi, yet the delicate cell walls show no displacement or distortion. There is no indication whatever that the fungus causes any pathological disturbance or is in any way obnoxious to the plant. On the contrary, the uniformity with

which it has been found to occur on healthy plants and its frequent absence or scarcity on sickly plants are facts suggestive of a beneficial influence. The nature of this beneficial influence is discussed on pages 48 to 50.

(16) **THE ACID PEATY SOILS IN WHICH THE SWAMP BLUEBERRY THRIVES ARE DEFICIENT IN "AVAILABLE" NITROGEN, ALTHOUGH CONTAINING LARGE AMOUNTS OF "NONAVAILABLE" NITROGEN.**

Ordinary agricultural plants absorb their nitrogen from the soil in the form of nitrates. Whether any are able to utilize directly other forms of nitrogen, particularly ammonia nitrogen, has been the subject of much experiment and of discussion by many authors. It is true in general, however, that the common plants of agriculture when their other food requirements are satisfactory make their growth in direct proportion to their ability to secure their nitrogen in the form of nitrates. For this reason the processes of agriculture are largely devoted to the securing and maintenance of conditions that will bring about the transformation of nonavailable nitrogen into nitrates. Soils in which this can not be done without great expense in proportion to their productiveness are generally considered poor.

The acid soils in which wild blueberries thrive are always looked upon as infertile in their natural state, and unless these soils are extensively manipulated cultivated plants do not do well in them. Whether or not a part of this infertility is due to the directly injurious effect of acid or other poisonous substances, it is known that the conditions existing in these soils are directly antagonistic to the formation of nitrates. (See p. 47.)

That kalmia peat, the soil found in these cultures to be most successful for blueberries, is deficient in nitrates, although containing an abundance of nitrogen in other forms, is shown by the following nitrogen determinations:

TOTAL NITROGEN IN KALMIA PEAT.

(Determinations made by Mr. T. C. Trescott.)

Sample.	Per cent.
1	0.95
2	1.46
3	1.18
4	1.15
5	1.40
6	1.12
Average of total nitrogen	1.21

NITROGEN IN KALMIA PEAT IN THE FORM OF NITRATES.

(Determinations made by Mr. Karl F. Kellerman.)

Sample.	Per cent.
7	0.0012
8	.0022
9	.0008
10	.0013
11	.0025
12	.0008
Average of nitrate nitrogen	.0015

(17) THE DEFICIENCY OF AVAILABLE NITROGEN IN THE ACID PEATY SOIL IN WHICH THE SWAMP BLUEBERRY GROWS BEST IS DUE TO THE INABILITY OF THE NITRIFYING BACTERIA TO THRIVE IN SUCH A SOIL BECAUSE OF ITS ACIDITY.

In order to understand the conditions antagonistic to nitrification which exist in good blueberry soils it is necessary first to discuss the source and transformation of nitrogen in ordinary soils.

The available nitrogen in the soil, such as is absorbed by an ordinary plant, is commonly derived, unless fertilizers have been applied, from the decomposition of the humus contained in the soil, and the humus is itself a product of the decomposition of plant and animal remains. These remains consist ordinarily and chiefly of the partially rotted leaves, stems, and roots of plants.

In the older agricultural literature the name humus was applied to a particular kind of soil which is more properly covered by the terms vegetable mold, leaf mold, and woods mold. (See p. 24.) Later the application of the word humus was restricted to that portion of a soil consisting of the plant and animal remains, in whatever stage of decomposition. The proper designation of these remains is, however, organic matter. In the sense just described the word humus is still frequently used, but not with correctness and precision. Humus, as now understood by agricultural chemists, represents a stage in the decomposition of organic matter in which the cellular structure has wholly disappeared and the original substance is or at some stage has been entirely dissolved.

Since it is often necessary to allude to organic matter in the earlier stage, as distinguished from organic matter as a whole, which includes the humus stage as well, the term cellular organic matter, or, more simply still, cellular matter, is suggested as a convenient designation. In cellular matter the cellular structure of the animals or plants still remains and may be detected either by the eye or by the microscope.

Humus, which is a complex mixture of diverse substances, does not ordinarily exist in the soil in a dissolved condition, but is usually combined with lime or magnesium. The resultant compounds, often indiscriminately blanketed under the names calcium and magnesium

humate, are not soluble in water, but form a usually black precipitate, which gives a dark color to the soil.

To extract its humus a soil is first washed with dilute acid, by which the lime, magnesium, or other humus-precipitating substance is dissolved and leached away. The humus itself is then removed from the soil by long-continued washing with a weak solution, commonly 4 per cent, of ammonia. Upon the application of this treatment to kalmia peat an inky-black extract is secured. When this is evaporated to dryness the residue is a black substance which when scraped from the dish resembles coal dust or, even more closely, burned sugar. This substance is one of the forms of humus. It absorbs water readily, assuming the texture of thin jelly. It has a somewhat sooty odor and taste. It dissolves in water, the solution being acid in reaction. A liter of water in which had been dissolved a gram of humus extracted from kalmia peat showed when tested a 0.002 normal acidity. Such a solution is black unless viewed in a thin layer, and when diluted to 10,000 c. c. it has a brown color similar to that of ordinary cider vinegar. If lime is added to the solution the humus unites with it and is thrown down as a black precipitate, leaving the liquid clear. As stated in the preceding paragraph, it is in such a precipitated and neutral or alkaline form that humus ordinarily occurs. The characteristic brown color of the water in bogs indicates an acid condition, the presence of humus in solution, and the absence of soluble lime.

The process of decomposition by which cellular matter is transformed into humus, in which the cellular structure has entirely disappeared, is known as humification.

Humus contains nitrogen, but the nitrogen is not in the form of nitrates and therefore can not be assimilated by ordinary plants. The transformation of humus nitrogen into nitrates occurs during a further process of decomposition known as nitrification.

The nitrification of humus is brought about by certain bacteria which, growing in the humus-laden soil under suitable conditions, produce first ammonia, then nitrites, and then nitrates. In artificial cultures, in addition to proper conditions of temperature, moisture, and good aeration, these nitrifying bacteria require for vigorous growth a neutral or slightly alkaline medium. In a distinctly acid medium the nitrifying bacteria grow little or not at all.

In order to ascertain the degree of nitrification, if any, taking place in kalmia peat, a series of nitrification tests of this material was made by Mr. Karl F. Kellerman. These tests showed that neither in fresh peat nor in peat rotted for three months was nitrification in progress, but when the acidity of the peat was neutralized by the addition of lime nitrification began.

(18) FROM THE EVIDENCE AT HAND THE PRESUMPTION IS THAT THE MYCORRHIZAL FUNGUS OF THE SWAMP BLUEBERRY TRANSFORMS THE NONAVAILABLE NITROGEN OF PEATY SOILS INTO A FORM OF NITROGEN AVAILABLE FOR THE NOURISHMENT OF THE BLUEBERRY PLANT.

It is a well-established principle of plant physiology that (with the possible exception of a few bacteria) those plants which contain no chlorophyll, the green coloring matter of leaves, are unable to grow with mineral nutrients alone, since they are unable to manufacture their own carbohydrates. Plants without chlorophyll, including the fungi, are dependent for the fundamental part of their nourishment on the starch or other related carbohydrates originally elaborated from carbon dioxid and water by the chlorophyll-bearing plants. They also differ from the higher plants in being able to supply their nitrogen requirements directly from organic nitrogen compounds.

Fungi may be directly parasitic on a chlorophyll-bearing plant, as in the case of the mildew fungus of rose leaves, or they may grow on substances derived from chlorophyll-bearing plants, such as bread or jelly.

Fungi are particularly abundant in the decaying vegetable matter forming the leaf litter of a forest, even though this litter may be distinctly acid in its chemical reaction. They are known, indeed, to grow luxuriantly on vegetable remains containing no nitrates and of such acidity that nitrification, or the conversion of the humus nitrogen into nitrates by means of bacteria, can not take place.

That the mycorrhizal fungi, like other fungi, are able to extract nitrogenous food from the nonnitrified organic matter with which their external portions are in contact is a reasonable supposition. It is furthermore a reasonable supposition that the blueberry plant is able to absorb nitrogenous material from the internal portion of its mycorrhiza; for we know that the clover plant is able to absorb nitrogen under essentially the same conditions from the nitrogen-fixing bacteria growing in its root tubercles.

To establish by direct experiment the ability of the mycorrhizal fungus of the blueberry to act in accordance with the supposition outlined above, the fungus should be separated from the plant and grown by itself in suitable nutrient media. Preliminary trials were made to isolate the fungus, but without success, and a lack of time has prevented thus far the pursuit of that branch of the experiments.

(19) IT IS POSSIBLE THAT THE MYCORRHIZAL FUNGUS OF THE SWAMP BLUEBERRY TRANSFORMS THE FREE NITROGEN OF THE ATMOSPHERE INTO A FORM OF NITROGEN SUITED TO THE USE OF THE BLUEBERRY PLANT.

The fact of the fixation of atmospheric nitrogen by the bacteria inhabiting the root tubercles of clovers is now well known, and we are able to understand how the abundant nitrogen of the air, unavail-

able for the direct nutrition of ordinary plants, is made available for the use of leguminous crops.

It is not so generally known that there are in soils certain species of bacteria not connected with the roots of plants which also possess the faculty of taking up the nitrogen of the air and making it over into plant food. The extent of the distribution of these organisms and the amount of nitrogen fixation effected by them are not fully known, but the fact that such action does take place and that the bacteria causing it occur in many localities has been well established by the experiments of several investigators. The bacteria of this class most fully investigated are *Clostridium pasteurianum*, *Azotobacter chroococcum*, and several other species of this latter genus.

It has been shown also that certain fungi, such as *Penicillium glaucum*, possess this same power of assimilating atmospheric nitrogen.

After the writer had discovered the mycorrhizal fungus of the swamp blueberry in December, 1907, and while he was making observations on it, his attention was called to the work of Miss Charlotte Ternetz on the mycorrhizal fungi of certain related European plants. Miss Ternetz published in 1904 a paper[a] in which she made the preliminary announcement that a fungus isolated from the roots of the European cranberry (*Oxycoccus oxycoccus*) had developed pycnidia and that the mycelium produced from spores from these pycnidia when grown in a nitrogen-free nutritive solution, but with full access to air, showed upon analysis that it had assimilated free atmospheric nitrogen to the extent of 0.6 per cent of the dry weight of the mycelium. The fungus consumed only one-eighth as much dextrose in assimilating a given amount of nitrogen as was consumed by *Clostridium pasteurianum*. Similar but not identical fungi were isolated from other related plants.

In 1907, in a more detailed account of her investigations,[b] Miss Ternetz described, as new species of Phoma, five pycnidia-bearing fungi bred from the roots of the European cranberry (*Oxycoccus oxycoccus*), the marsh rosemary (*Andromeda polifolia*), two species of heather (*Erica tetralix* and *E. carnea*), and the mountain cranberry (*Vaccinium vitisidaea*). She was unable to demonstrate absolutely that these fungi were identical with the endotrophic mycorrhiza of the host plants because (1) it was extremely difficult to observe the fungous threads of the internal mycorrhiza grow through the cell wall of the rootlets into the culture medium without, and (2) be-

[a] Ternetz, Charlotte, Ph. D. Assimilation des atmosphärischen Stickstoffs durch einen torfbewohnenden Pilz. Berichte der Deutschen Botanischen Gesellschaft, vol. 22, 1904, pp. 267–274.

[b] Ternetz, Charlotte, Ph. D. Ueber die Assimilation des atmosphärischen Stickstoffes durch Pilze. Jahrbücher für Wissenschaftliche Botanik, vol. 44, 1907, pp. 353–408.

cause when she proposed to inoculate mycorrhiza-free seedlings of the host plants with spores from the pycnidia that formed in her cultures she was unable to grow any seedlings that were free from mycorrhiza.

Notwithstanding the lack of an absolute demonstration that the nitrogen-fixing fungi grown by Miss Ternetz were identical with the mycorrhizal fungi of their hosts, it is regarded as quite possible that the mycorrhizal fungi that occur in perhaps all plants of the heather and blueberry families, including the swamp blueberry, are nitrogen fixers, and that the host plants absorb this nitrogen, giving in exchange, for the use of the fungus, sugar or some other carbohydrate.

The experiments thus far described in the present paper, and the accompanying discussions, appear to warrant the following theory of the method of nutrition of the swamp blueberry:

(*a*) The swamp blueberry grows in peaty soils which contain acid or other substances poisonous to plants.

(*b*) As a protection against the absorption of amounts of these poisons great enough to prove fatal, this plant, like many other bog and acid-soil plants, is devoid of root hairs and consequently has a restricted capacity for absorbing soil moisture. This low absorptive capacity is correlated with a low rate of transpiration. Many bog shrubs, although living with an abundant supply of moisture at their roots, have been recognized as showing adaptations for retarded transpiration similar to desert plants.

(*c*) The special danger to which the swamp blueberry is exposed by reason of its low transpiration and its corresponding reduced capacity for absorption is insufficient nutrition. The danger of nitrogen starvation is particularly great since these soils contain very little nitrates.

(*d*) Some bog plants similarly threatened with insufficient nutrition, such as the sundews (Drosera), the bladderworts (Utricularia), and the pitcher plants (Sarracenia), possess means of securing the requisite nitrogen by catching insects and digesting and absorbing their nutritive parts.

(*e*) In the swamp blueberry the required nitrogen is secured in a different way. The plant associates with itself a mycorrhizal fungus which is able to assimilate nitrogen from the surrounding organic matter, and perhaps from the atmosphere also, and to convey it into the plant without taking along with it a large amount of the poisonous soil moisture.

Whether this theory of the nutrition of the swamp blueberry is or is not substantiated in all its details by future investigation, it has afforded a useful basis for cultural experimentation, as will be evident from the results about to be described.

A METHOD OF POT CULTURE.

(30) SEEDS OF THE SWAMP BLUEBERRY SOWN IN AUGUST FROM FRESH BERRIES GERMINATE IN ABOUT FIVE WEEKS.

The experiments in the raising of blueberry seedlings have covered such a great diversity of soil mixtures, methods of potting, manner of watering, amount of shade, and day and night temperatures that an account of all of them is out of the question. The more important results of these experiments may be presented, however, in an account of the seedlings of 1908, the latest that have been grown for an entire year, with allusions to the experiments of other years whenever additionally useful. The parent plant of the seedlings of 1908 is described on page 80.

The method followed in germinating the seed was that developed by Mr. George W. Oliver, of the Bureau of Plant Industry, in 1902. All other experimenters, apparently, have considered it necessary to keep the seeds dormant by stratification or some equivalent means until late winter or early spring and then to give them the warmth necessary for germination. By Mr. Oliver's method, however, the seeds are sown in August, soon after the maturity of the berries; they begin to germinate in about five weeks, and by proper handling in the greenhouse they are robust plants by the beginning of summer instead of tiny seedlings.

Pursuing this method the detailed operations were as follows: The berries (Pl. VI, fig. 1) when fully matured and slightly fermented were mashed to a pulp and rubbed thoroughly under water. The juice and floating pulp were washed away, and the heavy seeds, which sank to the bottom, were taken out and their superficial moisture dried off by exposure to the air for a few hours. When thus prepared and placed in a closed bottle blueberry seeds will retain their vitality for several weeks, probably for several months.

From the 2 quarts of berries were secured 12.5 grams of dry seeds. The seeds numbered about 9,000 per gram, of which about three-fourths were small and contained no embryos. About 11 grams were used to raise seedlings, computed to contain about 25,000 germinable seeds. It furnished an abundant amount for seeding four ordinary gardener's flats, and from these over 1,000 seedlings were actually transplanted and as many more might easily have been utilized.

The mature seeds (Pl. VI, fig. 2) are roughly orbicular to narrowly oblong in outline, strongly flattened, with a deeply pitted seed coat. They vary in length from 0.04 to 0.06 of an inch (1 to 1.5 mm.).

The seeds were sown in shallow wooden flats 10 by 34 by 3 inches, inside measurement. After crocks had been placed over the drainage holes the bottom was covered to a depth of about an inch with

kalmia peat in fibrous form to insure good drainage. Over this was placed the finely sifted soil of the seed bed, trodden down with the whole weight of the body, the total thickness of the soil and drainage being 2.5 inches.

The soil of the seed bed in this instance was a mixture of the following, each rubbed through a wire sieve with $\frac{1}{16}$-inch square openings:

Kalmia peat	8 parts by bulk.
Sand	2 parts by bulk.
Live sphagnum	2 parts by bulk.
Loam	1 part by bulk.

While this mixture gave good results, certain modifications in the direction of simplicity have been found equally satisfactory so far as growth is concerned, and more satisfactory with regard to the ease of transplanting. These changes involve the omission of the loam, which from other experiments is now regarded as never advantageous and sometimes actually injurious, and the omission of the sphagnum, which, although a good moisture-holding and aerating medium, appears to be superfluous in a peat and sand mixture. The sphagnum also interferes somewhat with the clean pricking out of the seedlings in the first transplanting. From experience with various other seedlings of blueberries a mixture of 2 parts of finely sifted kalmia peat to 1 part of sand is regarded as satisfactory and preferable. The peat should be well rotted and the sand clean and free from lime. This matter is more fully discussed on page 60.

After the seed bed had been prepared, as already described, the dry seeds were scattered upon it and covered with about an eighth of an inch of the same soil lightly sifted over it. The surface was then sprinkled with water from a sprinkling pot provided with a very fine rose.

So far as moisture is concerned the ideal condition of the seed bed is that the soil should be just damp enough so that it shall not become dry on the surface. The drying of this peat is indicated by a conspicuous color change, from dark brown to light brown. If exposed directly to an ordinary greenhouse atmosphere, the tendency of the seed-bed surface to become dry will necessitate frequent applications of water, and the bed will be in danger of repeated periods of sogginess. These conditions may be very much improved by covering the flat with panes of glass. An opening about an inch wide should be left at either end to permit the circulation of air over the seed bed. This ventilation will prevent the excessive accumulation of moisture in a stagnant atmosphere and will also prevent overheating on sunny days, both of which conditions are injurious to seedlings. A flat thus covered may not require watering for intervals of several days. The advantages of the glass covering are par-

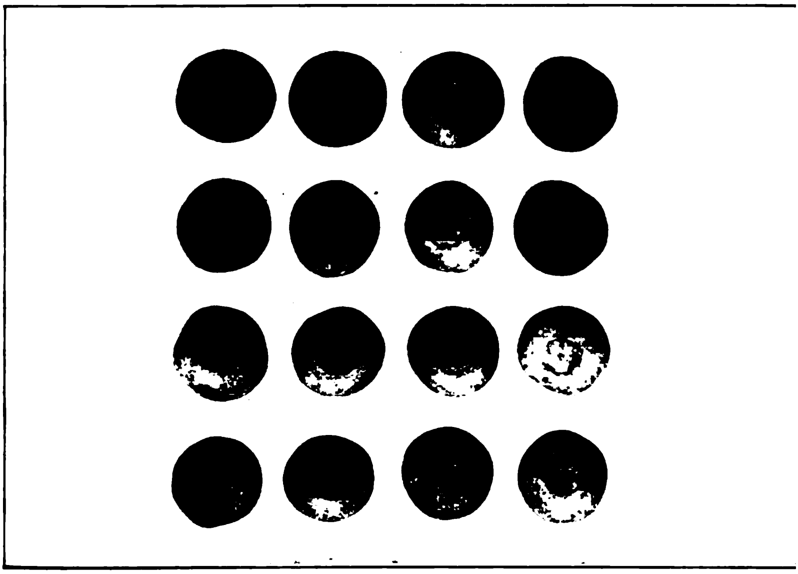


FIG. 1.—SWAMP BLUEBERRIES FROM THE PARENT BUSH OF THE SEEDLINGS OF 1908.

The berries were photographed after remaining nearly a year in formalin, and the illustration does not show their maximum size and plumpness. (Natural size.)

FIG. 2.—SEEDS OF THE SWAMP BLUEBERRY.

(Enlarged 10 diameters.)

ticularly evident when germination begins, for many of the seeds have been washed to the surface in the process of watering and have germinated without any soil covering. It may be several days before the root penetrates the soil, but the moisture maintained in the air underneath the glass keeps these naked seedlings from death by drying. After germination has progressed so far that a good stand of seedlings is assured the glass should be gradually removed.

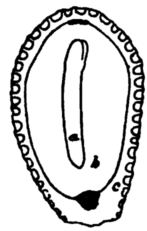


FIG. 19.—Section of a blueberry seed: *a*, Embryo; *b*, endosperm; *c*, outer seed coat. (Enlarged 18 diameters.)

The flats seeded on August 12, 1908, were kept in a greenhouse as cool as practicable and shaded from the sunlight. When started in winter, seed flats should be kept at a temperature not less than 50° to 60° F. at night and about 15 degrees higher in the daytime. Under such conditions sunlight during the whole day seems to benefit them.

Germination began on September 18, thirty-seven days after seeding, and continued for more than two months. In other seedings of this and the closely related blueberries known as *Vaccinium atrococcum* and *V. pallidum*, germination has begun in as short a period as twenty-five days. This slowness of germination might be considered merely a feature of the general sluggishness of growth in these plants. It is in fact, however, due to a much more specific cause. The food stored in the seed for the nourishment of the plantlet is not located in the cotyledons, as in the bean or pea, for example, but it lies in a mass called the endosperm, quite outside the embryo. (See fig. 19.) It requires several weeks for the minute embryo, feeding on the large mass of surrounding endosperm, to grow to sufficient size to burst open the seed coats. Until the embryo has attained such size it is physically impossible for the seed to germinate.

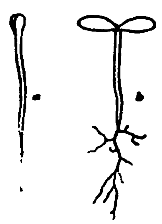


FIG. 20.—Blueberry seedlings in the cotyledon stage: *a*, Before the expansion of the cotyledons; *b*, at the beginning of the development of the first foliage leaf. (Enlarged 2 diameters.)

When the seedlings had straightened themselves out they were about 0.2 to 0.3 of an inch (5 to 8 mm.) high and the newly expanded cotyledons about 0.06 of an inch (1.5 mm.) long. (See fig. 20.) Within a few days the first foliage leaf began to appear between the cotyledons about 0.06 of an inch (1.5 mm.) long. (See fig. 20.) inch (10 to 15 mm.) high, the erect unbranched stem bearing four or five foliage leaves, and the cotyledons having expanded to a length of 0.12 of an inch (3 mm.). (See fig. 21.)

Although the leaves of the parent plant had entire margins, the leaves of the young seedlings were invariably serrulate. It was only after the plants were several months old that any of the branches began to produce leaves with entire margins, and some of the seedlings from this parent give promise of permanently retaining the serrulate leaf character. (See p. 82.)

(21) THE SEEDLINGS ARE FIRST TRANSPLANTED AT THE AGE OF ABOUT SIX WEEKS, WHEN THEY ARE APPROACHING AN INCH IN HEIGHT.

On October 24 the first transplanting was done from the seed flats of 1908. A new flat was filled to a depth of 2 inches, trodden down hard, with the following mixture:

Kalmia peat, rotted for several months and rubbed through a quarter-inch sieve	8 parts by bulk.
Sand, coarse, washed	1 part by bulk.
Loam, clayey, finely sifted	1 part by bulk.

This soil mixture was used as the result of experience of the two preceding years. From a few experiments made in the winter of 1906–7 it had been found that a mixture of equal parts, by bulk, of peat, sand, and loam was decidedly superior to loam and manure or to sand, sphagnum, and loam. In the winter of 1907–8 it was found that the amount of sand and loam could be reduced with distinct advantage, and as a result of the experiments then made many of the cultures of 1908–9 were grown in the mixture described above (peat 8, sand 1, loam 1). The retention of the loam was due to an idea that this ingredient would furnish some necessary mineral nutrient not furnished by the peat. From an experiment made in the summer of 1909, however (p. 69), it was found that under the system of handling the pots described on page 67 large plants repotted in a peat soil with no loam whatever made a better growth than those potted in a peat containing a tenth part of loam. There is some reason, therefore, to suspect that loam, even in such a small quantity, may be slightly injurious, and more reason to suspect that it may be superfluous. Experiments intended to throw light on this question are now in progress.

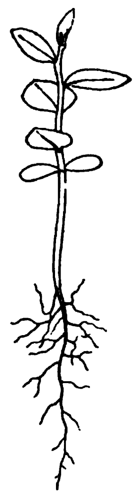


FIG. 21.—Blueberry seedling about six weeks old, with five foliage leaves. (Enlarged 2 diameters.)

In the soil of the flat, prepared as described above, 80 plants were set 2 inches apart. They were pricked out of the seed bed and set

in the new soil by means of a small dibble. These plants were half to three-fourths of an inch high and had three to six true leaves.

It is believed that a spacing of 2.5 inches in the flat is better than 2 inches, as the plants have a little more room and the 2.5-inch square of earth is a very convenient size when the next transfer is made into 4-inch pots.

From this time on during the winter the plants were kept in a cool greenhouse in which the night temperature was 55° to 60° F., and which was given a large amount of ventilation. The day temperature reached ordinarily 65° to 70° F. It was found that a house with a night temperature of 40° F. and a day temperature of 60° F. was too cold for such seedlings, as they made almost no growth at all. In a warm house, 65° to 70° at night and 80° to 90° F. in the daytime, blueberries grow fairly well, but they are much subject to injury by red spider (*Tetranychus bimaculatus*), and their new growth while sufficiently extensive does not appear so robust as in the 60° to 70° F. house.

For the first few days the newly transplanted seedlings were sheltered from direct sunlight. Later, however, they were given all the sunlight possible. It was found that during the winter, when well established in a suitable soil and under proper moisture conditions, the plants grew better when they received the fullest sunlight that the greenhouse afforded. This statement applies to the plants in all stages, whether in a seed bed or after the first transplanting or in larger pots.

In watering, the plants should be kept "on the dry side," as gardeners say. Water may advantageously be withheld until the surface of the soil is dry, but this condition should not be allowed to extend to a depth of more than about an eighth of an inch. Then a rather thorough watering should be given, which will carry moisture to the bottom of the soil, but not run through. Such a watering at infrequent intervals is preferable to frequent light sprinklings that moisten the surface only. Except for the brief period of percolation immediately after watering, the movement of water in the soil should be a capillary one, and from the bottom upward. Under such conditions, if the soil is of proper texture, good aeration is insured.

The shock of transplanting checks the growth of the seedlings for several days. This checking of growth may manifest itself in one or more of three ways: (*a*) The withering of the stem tip; (*b*) the "stagnation," or stoppage of expansion of the uppermost leaf rudiment; and (*c*) the purpling of the older leaves. As these phenomena when persistent have been much utilized in these experiments as warnings of the existence of conditions antagonistic to growth and as they may be of similar assistance to other experimenters, a description of them will be given.

The withering of the tip includes the uppermost leaf rudiment and the growing point of the stem inclosed within its folded base. The tissues turn brown and become dry, and the growth of that axis is terminated. The resumption of growth from such a stem, if it occurs, takes place through the formation and expansion of a bud in the axil of the leaf next below the withered one. This withering of the tip is readily distinguishable by its color from a partial blackening of the uppermost tender leaves which sometimes occurs, apparently a pathological disturbance of a temporary character and usually not affecting the growing point of the stem itself. The brown withering of the tip seldom takes place when the leaf rudiment involved in the withering is more than 0.1 inch (2.5 mm.) in length. When longer than that it usually keeps on expanding. This withering of the tips has been almost wholly prevented when the shock of transplanting was rendered as light as possible by suitable precautions, including (*a*) a soil in perfect condition for the nutrition of the plants, especially that in which the peat is well rotted (p. 61); (*b*) the transfer of the plants to their new bed without injury, especially without destroying any part of the roots; (*c*) the shading of the plants from direct sunlight for two weeks or more, until their new root growth is well established, and their subsequent gradual adjustment to full sunlight; and (*d*) the holding of the transplanted plants in a warmer, moister atmosphere, about 65° at night and 80° F. in the daytime. Whether or not this last condition had a real influence on the prevention of the tip withering is not definitely known.

The stagnation of the uppermost leaf rudiment does not attract the inexperienced observer's attention so readily as its withering. With a little experience, however, it is easily detected. Ordinarily the leaves of a growing stem follow each other at a rather close interval, so that by the time a half-grown leaf is ready to flatten out, from its boat-shaped folding in the younger stage, the succeeding leaf is commonly a third or more the length of the one that is flattening (fig. 22). When stagnation occurs, however, the uppermost leaf rudiment promptly stops growing, usually at a length of 0.04 inch (1 mm.) or less, while the young leaf next below it goes on flattening and growing to nearly its normal size. The end of the stem, therefore, shows a nearly full-grown flat leaf with a minute leaf rudiment at its base seldom more than a fifth and often not more than a tenth its own length.

The purpling of leaves, to which allusion has been made, does not refer to the reddish translucent appearance of the growing twig tips. That is the normal coloration in the blueberry, as it is, for example, in the rose. The purpling now under consideration occurs in the mature leaves, which are normally green, and is of a dark shade. It is commonly accompanied by a conspicuous reddening of the leaf

veins. This purpling of the old leaves is evidence of a severe stoppage of growth and in these experiments has been observed to be caused by low temperature, about 40° F. or lower, or by lack of nutrition from any cause, or, apparently, by poisoning.

If the soil into which young blueberry seedlings are transplanted is suited to their growth, purpling of the old leaves seldom occurs, the evidence of the shock of transplanting being confined to the possible withering of a few of the stem tips and the temporary stagnation of others. In some transplantings no withering of tips occurs.

During the period of cessation of stem growth after transplanting, the plant is by no means idle, for the roots, as shown in glass-pot cultures, continue to make new growth, and when this has sufficiently progressed stem growth is resumed.

(22) WHEN ABOUT TEN WEEKS OLD AND NEARLY TWO INCHES IN HEIGHT THE SEEDLINGS BEGIN TO SEND OUT BASAL BRANCHES.

An important phase in the development of the seedlings of 1908 began on November 25, when one of the plants commenced to send out a branch from the axil of a cotyledon. At the expiration of another month 75 per cent of the plants in the flat had put out similar basal branches, and the remaining 25 per cent ultimately did the same.

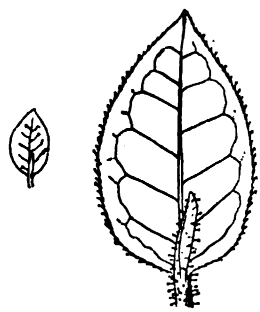


FIG. 22.—Normal tip of stem in a blueberry seedling. (Enlarged 4 diameters; the smaller figure natural size.)

These basal shoots are of the highest importance in the economy of the blueberry plant, for they soon far outstrip the first stem and become the principal seat of growth, until they themselves are overshadowed by later and still more vigorous basal shoots. The original stem of the seedling never develops into an ultimate main stem or trunk, but, as will be seen later (p. 58), stops growing while the plant is still young, and afterward dies. It is this habit of sending up basal shoots that makes the swamp blueberry a many-stemmed bush, not a miniature tree with a single trunk.

The development of basal shoots began when the seedlings had about 12 leaves and were about 1.5 to 2 inches high. In this first basal branching the number of branches varied from 1 to 3. Out of 73 plants on which the branching was recorded 39 had 1 branch, 30 had 2 branches, and 4 had 3 branches. The branches occurred in the axils of the cotyledons or of one of the first four leaves. Of the 39 plants with 1 branch, 11 had the branch in the axil of a cotyledon, 17 in the axil of the first leaf, 8 the second, 2 the third, and 1 the fourth. Of the 30 plants with 2 branches, 11 had both branches in

the axils of the cotyledons, 13 had neither branch so situated, and 6 had 1 branch from a cotyledon axil and 1 from a leaf axil. Of the 4 plants with 3 branches, 3 had all 3 branches in the axils of the cotyledons and the first leaf, 1 had a branch in the axil of a cotyledon and of the first and second leaf. Of the total 111 branches 46 were in the axil of one of the two cotyledons, an average of 23 to each, 36 in the axil of the first leaf, 20 the second, 7 the third, and 2 the fourth. In the order of the frequency of production of a basal shoot, therefore, the first leaf stands first, a cotyledon next, then the second, third, and fourth leaves, in order.

While the exact location of the basal branches appears to have no special significance, the number of the branches does, for the habit of producing two or more branches is a persistent one and such seedlings tend to produce diffuse plants with many and small stems and small stature, while the plants with the single-branch tendency are taller and have fewer and more robust stems. The differences in general appearance caused by the two types of branching are well illustrated in figures 24 and 25, from photographs of two seedlings of 1907 made at the age of 10 months.

(23) When the seedlings are about four months old and about three inches in height the growth of the original stem terminates.

On January 5, 1909, the growing tip on the original stem of one of the plants withered. At that time this stem was about 2.5 inches high, had 14 leaves, and had 2 vigorous basal shoots about an inch in length. This withering differed in one important respect from the withering due to shock, described on page 56. In that case it was an ordinary leaf rudiment that withered. In the present case the withering was foreshadowed by the development of a minute bract (fig. 23). This differed from the ordinary leaf rudiment in the absence of the glandular hairs characteristic of young leaves, and it remained small until the leaf next below it had become more than ten times as long. Then the bract withered and the growth of the original stem was permanently terminated. The same development went on in the other plants until at the end of a month 65 per cent and in two months 95 per cent of the plants had terminated the growth of their original stems.

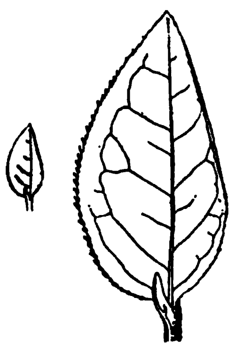


FIG. 23.—Bract and young leaf at the end of the original stem in a blueberry seedling. (Enlarged 4 diameters; the smaller figure natural size.)

In the individual plant the termination of growth on the original stem took place after the basal shoot or shoots had reached a stage of

vigorous development. Out of fifty-nine normal cases observed prior to the second transplanting of the seedlings, the length of the new shoot, or when more than one the longest of them, at the time of termination of growth on the old stem varied from 0.4 of an inch to 5 inches, with an average of 1.8 inches. It would appear that the

FIG. 24.—Blueberry seedling with diffuse type of branching. This will become a low, many-branched bush. (One-third natural size.)

FIG. 25.—Blueberry seedling of the type with few branches. The branch is more than twice as tall as the original main stem. (One-third natural size.)

immediate cause of the termination of growth on the old stem is the diversion of food materials into the new vigorous growth.

(24) WHEN THE PLANTS ARE ABOUT FIVE MONTHS OLD AND FOUR TO SIX INCHES IN HEIGHT THEY ARE POTTED IN FOUR-INCH POTS IN THE BEST PEAT OR PEAT MIXTURE.

On February 17, when the plants were 4 to 6 inches high, they were transplanted into 4-inch pots in the same soil mixture as was used in the transplanting of October 24 (peat 8, sand 1, loam 1). As stated

in the discussion of that transplanting, the plants would probably have done somewhat better without the loam. In addition to the crock over the drainage hole, a mass of fibrous kalmia peat was placed in the bottom of the pot, filling it, when pressed down, to the depth of an inch or more. After cutting the soil in the flats into rectangular cakes, the plants were lifted and transferred to the pots with the least possible disturbance of the roots.

Several experiments had been made earlier to ascertain whether at the first transplanting from the seed bed it is better to set the plants in flats or to put them in 2-inch pots, or thumb pots as they are more commonly called. It was found that when the plants in thumb pots were set on a greenhouse bench they tended to dry out so rapidly that it was impracticable to keep them in the right condition of moisture. They became so frequently too wet or too dry that their growth was interrupted and they were much inferior to the plants in the flats. Other plants in thumb pots (Pl. VII), plunged in either sand, peat, or sphagnum, made about the same growth as the plants in the flats, but showed no uniform advantage over them, either while they were in the thumb pots or after a second transplanting. The labor of transplanting and of maintaining uniform moisture is somewhat greater in the case of the potted plants. All things considered, in the original transplanting the use of flats is regarded as preferable to 2-inch pots.

It is desirable to consider at this time the exact qualities of the soils used in the potting mixtures. As already stated, it is regarded as preferable to omit the loam.

The sand should be free from lime, as most sand is, in fact. It should also be as clean as possible. If the only sand obtainable is mixed with clay, this should be removed by repeated washing in water.

The condition of the peat should also be carefully considered, as shown by the following experience during the progress of these experiments. From the seedlings of 1908 many series of transplantings were made on various days in October, November, and December. In the latter part of December it was noticed that while in some of the transplantings the seedlings were growing vigorously, other cultures were not doing well at all. Many of the tips were withered, over 25 per cent in some of the cultures; the rest became stagnated and dark purple, and remained so for nearly two months. All possible causes of the trouble having been eliminated except those due to the soil, the characteristics of the various soils used were considered with care. At this time the writer was possessed of the erroneous idea that lime in the minutest quantities was very injurious to the blueberry (p. 20), and consequently it was sus-

BLUEBERRY SEEDLING FOUR AND A HALF MONTHS OLD.

The original stem, erect in the illustration, has terminated its growth and is much exceeded by the vigorous basal shoot. (Natural size.)

pected that the sand was impure and contained lime. An examination of the sources of the different kinds of sand used showed that lime could not have caused the trouble. Finally, however, the various cultures were arranged by the dates of potting, and it was then found that the purpled plants had all been potted after a certain date, on which a new lot of peat had been received at the greenhouses. The peat in the earlier cultures had been received in June and at the time of the first transplantings had been rotting for four months at a warm summer temperature. The seedlings transplanted into this peat did not lose their tips, and growth was resumed almost immediately. The peat used after the middle of November was freshly gathered, and it was in this fresh peat that the seedlings suffered as already described. It should be stated here, however, that by the end of two months these seedlings, which meanwhile had been making good root growth, began to make rapid top growth also and later overtook their competitors.

Acidity tests of peat from the various cultures and in different stages of decomposition showed a remarkable correlation between the acidity of the peat and the behavior of the seedlings. In the fresh deleterious peat the acidity was excessive, varying from 0.03 to 0.046 normal. In the older peat in which the plants grew well the acidity was usually not in excess of 0.02 normal, in one case 0.024. Fresh peat rubbed through a quarter-inch sieve and showing an acidity of 0.034 normal had lessened its acidity to 0.02 normal after remaining in a moist well-aerated condition for three weeks in the warm air of a greenhouse. In view of these facts the conclusion was reached that the deleterious effect of fresh peat is due to its excessive acidity.

In the undisturbed peat of a kalmia thicket wild blueberry plants are often found growing luxuriantly. After this peat is stripped from the ground it becomes injurious, as has been shown, to blueberry plants that are potted in it, this injurious quality being correlated with an excessive acidity. The question arises, What causes this increase in acidity and in what particular part of the soil does it reside? It was at first suspected that the excessive acidity was located in the less decomposed upper layers of leaves which the roots of the blueberry plants in a wild state do not reach, but which, when the peat is rubbed through a sieve, go into the resulting mixture. The leaf layers to which reference is here made are not the uppermost, nearly dry layers a year or less old, for these are removed in gathering the peat, but the partially rotted layers one to two years old, such as those shown in Plate IV. An examination of such material showed that it was not excessively acid, but came well within the range of acidity beneficial to blueberry plants.

An acidity determination was then made of the roots in the peat. These are the roots, chiefly of oak and kalmia, that interlace the

partly decomposed portions of the peat into mats or turfs. Their appearance in the upper part of these turfs is shown in Plate V, figure 2. Taking some of these turfs, freshly gathered, the soil was all shaken from them, leaving only the "fiber," consisting entirely of these fine live roots. This fiber was allowed to rot for a few days, and an acidity test was then made. It proved to be 0.07 normal, an acidity far in excess of that which had proved injurious to the blueberry seedlings. The excessive temporary acidity of freshly gathered kalmia-peat turf and its consequent temporary injuriousness to blueberry plants are therefore attributed to the diffusion through the peat of the acids originating in the roots killed in the process of gathering the turfs.

It should be added here that the acidity of the uppermost layer of undecomposed leaves a year or less old is very great, and that care should consequently be exercised to keep these out of the soil used. A test of dry, brown, newly fallen sugar-maple leaves showed an acidity of 0.22 normal, and a mixture of the leaves of various species of oak in a similar condition, 0.4. Incidentally, attention may be called to the presumable efficiency of a mulch of such leaves in maintaining, by means of its leachings, under the influence of the natural rainfall, the acidity of the underlying more fully decomposed layers, which without the addition of fresh organic matter would ultimately become alkaline. (See the account of an alkaline oak-leaf mold on p. 35.)

(25) BLUEBERRY PLANTS POTTED IN PEAT MAY BE MADE TO GROW MORE RAPIDLY IF THEY ARE WATERED OCCASIONALLY DURING THE GROWING SEASON WITH WATER FROM A MANURE PIT.

In the winter of 1907–8 pottings of seedling blueberries from seeds sown in August, 1907, were grown in various greenhouses of the Department. The most successful of these pottings consisted of 89 plants in a mixture of peat, sand, and loam in 3-inch pots. Two of these plants are illustrated in figures 24 and 25. It had been supposed that the superior growth of these plants was the result of specially favorable conditions of light, temperature, and watering, as indeed it was in part; but in the following winter, during an inquiry about certain details of the handling of this culture, the gardener in charge of the greenhouse in which the plants were grown admitted that during a portion of the spring, without consultation, he had given the pots an occasional watering with manure water. As manure when used with loam in the winter of 1906–7 had proved positively injurious to blueberry plants, its possible beneficial effect when used in conjunction with peat seemed worth testing further. In the spring of 1909, therefore, various cultures were watered with manure water once a week, the amount applied being the same as that given in an ordinary watering with tap water, about 50 c. c. for

each 4-inch pot. The application was made to six cultures, containing altogether 156 plants, exactly comparable with a similar number of plants receiving no manure water. The applications were made in April and May and varied in number from five to eight.

In all six cultures the plants to which manure water had been applied made a more vigorous growth, temporarily at least, than those that received none.

Similar results were secured by the use of one-tenth cow manure, freshly rotted, in the peat mixture in which the plants were potted.

It was after the beneficial effect of this manuring had begun to show itself that a statement of similar results nearly a century old, in the culture of heaths, came to the writer's attention. It is contained in a book by William McNab entitled "A Treatise on the Propagation, Cultivation, and General Treatment of Cape Heaths," published in 1832. The original is now rare, but a reprint was published in 1908 in Notes from the Royal Botanic Garden, Edinburgh, volume 3, pages 351 to 374. McNab, who was the superintendent of the Edinburgh garden from 1810 to 1848, was undoubtedly the most intelligently successful grower of Cape heaths at the period of their greatest popularity. His treatise is original and practical and delightfully written. With reference to the manuring of heaths he states:

I may mention that I have used a small quantity of manure in the foregoing compost with very good effect, about one-eighth part of cow dung. This should be well rotted before it is used. The way that I have always prepared this dung before using it is to take a barrow load of it and place it in thin layers between layers of peat earth, and after it has lain for some time, chop the whole up together, and turn it over at intervals till the dung disappears and the whole mass assumes the appearance of black peat earth and sand; and where this manure is applied about an equal quantity of sand should be added (that is, about one-eighth part of the whole) in addition to the sand that I have before recommended to be mixed up with the earth. This, I know, can be used with very good effect, but for all ordinary purposes I consider it quite unnecessary, as there is no difficulty in growing heaths very soon too large for the accommodation that is generally allotted for them, with the compost that I have mentioned without manure. I merely mention this because I know it is the opinion of some that heaths will not thrive with manure added to the peat earth in which they are grown.

I know, however, that some heaths may be grown to a larger size, in the same space of time, with manure than without it; but, as I have already mentioned, I consider it quite unnecessary for all ordinary purposes, and any person who wishes to try its effects should do so very sparingly at first, till he is enabled to judge of the effect produced by it, as a little excess of manure is sure to injure the plants. Perhaps liquid manure might be used with very good effect for growing some kinds of heaths, but I am unable to give any particular directions in what proportion it should be used, as, from what trials I have made, I can not come to any certain conclusion. But this much I know, that whoever wishes to try it should do so at first with great caution, with quite as much as in using an excess of manure in its solid state.

McNab's conclusion that manure, while beneficial in small quantities, should be used with caution or not at all agrees with the conclusion reached from these blueberry experiments. On page 18 of this paper is described the disastrous results of the heavy manuring of blueberry plants, and in view of the fact that the blueberry makes satisfactory growth without manure and that we are not sufficiently informed of the exact conditions under which manure may become injurious, the use of even small amounts for blueberries is not now recommended.

A suggestion may be made, however, as to a possible reason for the injury of blueberry plants by manure. In the glass-pot experiment described on page 18, in which plants grown in a mixture containing half as much manure as peat made exceptionally good growth at first but soon died, the death of the plants was preceded by a rotting of the roots. Now, manure is alive with myriads of bacteria, while peat contains few. An examination of the two made by Mr. Karl F. Kellerman, from samples taken from the kalmia peat and the cow manure used in these experiments, showed 2,500 bacteria per plate in the

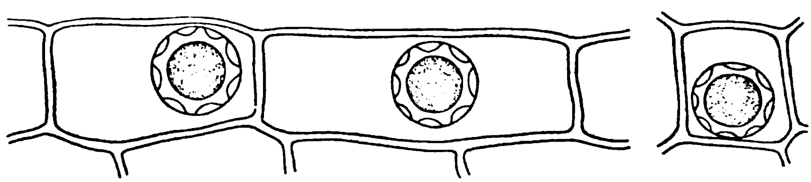


FIG. 26.—Spores of a supposedly injurious fungus in the epidermal cells of blueberry roots. (Enlarged 600 diameters.)

manure and 70 to 150 in the rotted peat, each plate representing 0.0004 of a gram of material. The bacteria in the peat were chiefly of two species, while the manure contained many. It is a reasonable supposition that the rotting of the blueberry roots may have been caused or aided by the bacteria in the manure or by some of the fungi with which manure is also abundantly charged. In mixtures like those recommended by McNab, however, containing much peat and little manure, the injurious bacteria and fungi in the manure may have been killed or held in check by the acids that exist in the peat and keep such organisms in control. If experiments show this theory to be correct, the application of manure to blueberries may then be made intelligently.

In this connection it may be well to call attention to a peculiar spore found in the roots of feeble blueberry plants grown in unfavorable soils, such as the limed peat and the clayey loam described on pages 23 and 24, and mixtures containing a large proportion of manure. In some of the epidermal cells of the rootlets were found large spherical bodies, as illustrated in figure 26. They usually occurred singly,

though occasionally two and rarely three were found together in the same cell. They were 0.0007 to 0.0008 of an inch (18 to 20 μ) in diameter, and in optical section showed an outer ring and an inner ring, with 6, 7, 8, 9, or 10 introrse scallops in the hyaline zone between them, the space within the inner ring being granular. These are evidently spores with a very thick wall, marked with a few large pits or depressions, and granular contents in the cell cavity. In what appeared to be later stages of development of these spores, the diameter was slightly larger, the wall was thin, the pits had disappeared, and the granular contents had become organized into minute spherical bodies, apparently incipient swarm spores, about 0.0001 of an inch (2 μ) in diameter, approximately one-tenth the diameter of the spore itself. Several of these large, thin-walled spores had put out a short germination tube and lost their contents, the spore remaining entirely hyaline and empty.

It was thought at first that these might be the reproductive bodies of the mycorrhizal fungus of the blueberry, but a careful search failed to show any connection between the two. It was observed, however, that in the rootlets containing the spores the interior cells usually presented a diseased appearance, the whole rootlet sometimes showing a brown streak down its middle, due to the decomposition of the vessels and wood cells. The inquiry into the nature of the spores was not pursued further, but the conditions strongly suggested that the spores were those of a parasitic fungus occupying the interior of the roots and causing, or associated with, their death and decomposition. The spores themselves bear a strong resemblance to the resting spores of *Asterocystis radicis*, a parasitic fungus of the family Chytridiaceæ. This fungus occurs in Europe in the roots of various plants, particularly flax, in which it is the cause of a serious disease.[a]

If an explanation is sought for the injurious effect of lime on the growth of the blueberry, the observations already made indicate the propriety of a careful study of this large-spored fungus, with special reference to the effect of lime in stimulating its growth and the growth of the other organisms of decay associated with it.

(26) Pots containing blueberry plants should be plunged in sand or other material that will furnish constant moisture and good aeration.

Although the plunging of earthen pots nearly to the rim in some moisture-holding material, such as sand, sphagnum, or peat, had been practiced for various purposes in several of the earlier cultures, and had been found essential (as stated on p. 60) for 2-inch pot cultures if rapid and uniform growth was to be secured, nevertheless the importance of applying the same practice to larger pots was not

[a] Marchal, Emile. Recherches Biologiques sur une Chytridinée Parasite du Lin. Bulletin de l'Agriculture, Brussels, vol. 16, 1900, pp. 511–554.

appreciated until the best culture from the 1908 seedlings had remained almost stagnant in 4-inch pots for over a month. The condition of the plants was first attributed to an excess of acidity in some of the peat used for potting, and next to the necessity of a period of rest from active growth. Neither of these reasons, however, it was ascertained from observation of other cultures, could account except in part for the distressed condition that these plants finally reached.

When one of the plants was knocked out of its pot it was invariably found that a large part of the roots at the sides of the earth ball were dead. It was at the period of the year, April and May, when the advent of warm sunny days made the control of temperature in the greenhouse somewhat difficult, and this, together with the previous rapid growth of the plants and the consequent increase of their water consumption, had brought about considerable irregularity in the moisture content of the pots. The conclusion was reached that the walls of the pots had become dry on one or more occasions, and that this had killed the delicate roots that came in contact with them. The roots of the blueberry, as described on page 42, are exceedingly slender, the smallest being about two-thousandths of an inch in diameter. They are very quickly killed by drying.

On the basis of this conclusion the general practice of plunging blueberry pots was adopted. If the plants are to be exposed to a very warm, dry atmosphere the plunging should be done before any considerable quantity of roots has grown through the soil to the wall of the pot. It is probably still better to do the plunging immediately after the potting, for then uniform moisture conditions can be secured throughout the soil in the pot.

Besides the avoidance of injury to the plants by the drying of their roots, the practice of plunging has another marked advantage, the maintenance of a moderate but adequate and even optimum degree of moisture in the soil with infrequent waterings. A series of pots plunged in live sphagnum in a cool greenhouse during the winter of 1908–9 frequently went for a week at a time without requiring water and then most of the water was applied between instead of in the pots. The moisture evidently moves freely in or out through the wall of the pot, which is of course not glazed, and an excess or deficiency in any one place is soon adjusted.

Sand has been found a convenient and satisfactory plunging material. The surface of the sand should come to the same level as the soil in the pot, or a little above it. A little sand on the surface of the soil does no harm, and indeed is probably advantageous. When a single pot is to be plunged it may be done by placing it within another

pot of 2 inches larger diameter, the space between the walls of the two pots being then filled with sand. (See Pl. XVIII.)

The practice of plunging has proved to be of the greatest importance in securing a large growth in potted blueberry plants, as will be appreciated from the description of the development made under such conditions out of doors in the summer of 1909. (See p. 68.) In that description special attention is drawn to the superior conditions of aeration in plunged pots.

(27) PLANTS OF THE SWAMP BLUEBERRY SOMETIMES LAY DOWN FLOWERING BUDS AT THE AGE OF SEVEN MONTHS.

The laying down of flowering buds is discussed in detail on pages 71 to 73, where a description is given of the general occurrence of this phenomenon in vigorous plants one year old. The first flowering buds, however, appeared much earlier. They were observed on April 8, 1909, on plants which were 10 days less than 7 months old. At the end of the 7 months 24 plants out of 258, which constituted seven of the most advanced cultures from the seedlings of 1908, had laid down flowering buds. A small percentage of the seedlings of 1907 had also laid down flowering buds at about the same age. The phenomenon may therefore be regarded as not rare in vigorous plants of this age.

These flowering buds, which contain the rudiments of about 7 to 12 flowers each, are not adapted to development into clusters of flowers until they have been subjected to a period of cold. Most of the buds, therefore, forming just as warm weather was approaching, withered and dried on the bushes. A few flowered in 1908 and in 1909, and in this latter year one plant bore ripe fruit on August 25, at the age of a little more than 11 months.

(28) IN THE SPRING AFTER THE DANGER OF FROST WAS PAST THE PLANTS WERE REPOTTED AND PLACED OUT OF DOORS, IN HALF SHADE, PLUNGED IN SAND.

On May 19 to 22, 1909, the seedlings of 1908 were repotted in 6-inch pots, in a mixture in most cases of peat 8, sand 1, and loam 1, and placed outdoors. The plants in the principal cultures had at this time an average height of about 9 inches, with a maximum of 15 inches. The pots were plunged in sand. They were in a situation where they were exposed to sunlight from about 8 o'clock in the morning to 5 o'clock in the afternoon, and to protect them from too great heat they were partially sheltered by a slat shade. The slats were 2 inches wide, with 2-inch openings between. As the sun struck the slats somewhat diagonally and they were half an inch thick, the plants when covered by the shades received a little less than half sunlight. On clear days the shades were kept over the plants from 9 o'clock to 4 o'clock. At other hours and on cloudy days the shades were removed. On August 25 the time of shading was shortened to the

period between 10 and 3 o'clock, and after September 12 the shades were left off altogether.

The plants were watered with a swift spray from a hose, the water being applied only when necessary to keep the soil from actually drying out. The sand between the pots was seldom allowed to become dry to the depth of more than half an inch. A sand mulch of about a quarter of an inch on the top of the soil in the pot was found useful in preventing the rapid drying of the soil by direct evaporation.

(29) BY THE USE OF THE CULTURAL METHODS ALREADY DESCRIBED, SEEDLINGS OF THE SWAMP BLUEBERRY HAVE BEEN GROWN INTO ROBUST PLANTS OF A MAXIMUM HEIGHT OF TWENTY-SEVEN INCHES AT TWELVE MONTHS FROM GERMINATION.

The growth of the plants out of doors during the summer was remarkably vigorous. Hitherto experimenters with seedling blueberries have been able to produce only comparatively small plants at the end of the first season, as shown by the following citation from a publication of the best-known experimenter:[a]

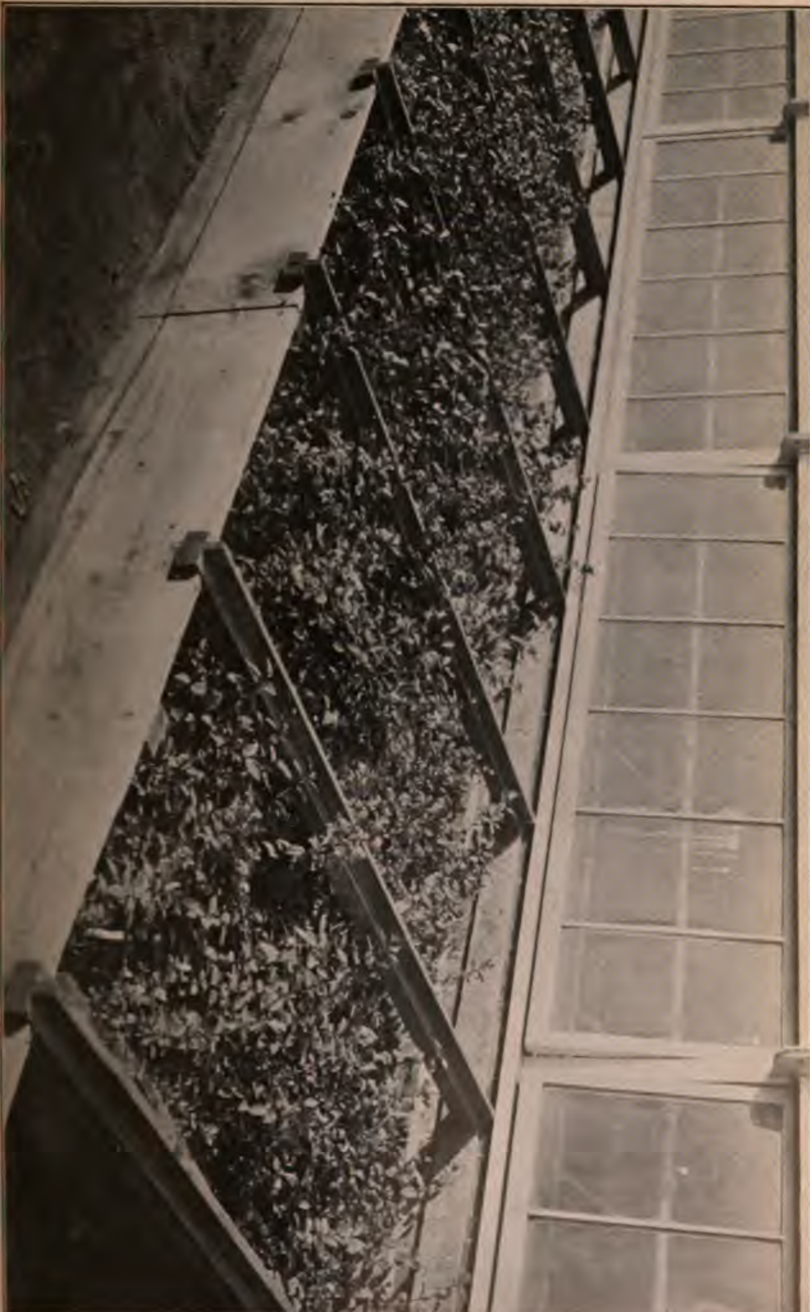
> The blueberry makes much less growth the first two years from seed than the huckleberry, but grows faster afterward. The third year I have had them make a growth of 6 to 8 inches. The low blueberry and huckleberry begin to bear at 3 or 4 years, while the high-bush blueberry requires 4 to 6 years. From 1 to 3 inches growth the first year is about all you can expect.

Under the system of treatment described in the present bulletin seedlings have been grown to a height of 27 inches at twelve months from germination. Out of the seedlings of 1908, 250 were carried through to the close of the season of 1909 in 6-inch pots. Of these, 15 were stunted plants. The remaining 235 had an average height at the end of the season of exactly 18 inches. The larger stems were often a quarter of an inch in thickness, and the main trunk, half submerged in the ground, sometimes reached a diameter of half an inch. The general appearance of these plants is shown in Plate VIII.

The principal features of cultural treatment which have contributed to this development are (*a*) the autumn germination of the seeds, (*b*) the use of suitable acid soils, (*c*) the plunging of the pots, and (*d*) the partial shading of the plants during the heat of summer, the application of these cultural methods having been guided throughout by the discovery of the existence of a mycorrhizal fungus in these plants and its treatment as essential to their nutrition. The system of germination and the character of the soils used have already been described in detail. The exact effects of the plunging and the shading remain to be considered.

It has already been shown (p. 66) that when a plant is not plunged, the minute rootlets that lie against the sides of the pot

[a] Dawson, Jackson. Cultivator and Country Gentleman, vol. 50, 1885, p. 600.



COLD FRAMES CONTAINING ONE-YEAR-OLD BLUEBERRY SEEDLINGS.

are very liable to death from dryness. When the pot is plunged in sand and the sand is kept moist these rootlets can not die from drought. They keep on growing until, in the case of vigorous plants, when the earth ball is knocked from the pot, the soil can not be seen because of the dense mat of live roots that line the pot. The same thick mass of live roots was developed in a series of 1907 seedlings carried over the winter of 1908–9 in the greenhouse in pots plunged in sphagnum. When the pot is surrounded by the moist plunging material these roots continue to luxuriate for months longer than they otherwise would. They evidently find the aeration conditions, as well as the moisture conditions, at the wall of the pot very satisfactory, for the development of roots there is far greater than within the ball itself.

The highly efficient aeration at the wall of plunged pots may explain one use of soils in which the results of the present investigations do not agree with the practice of the old heath growers. In one culture of 25 plants the soil used in the first potting was pure rotted kalmia peat rubbed through a quarter-inch screen. This first potting, in 4-inch pots, was done on March 20, 1909. The repotting, in 6-inch pots, was done on May 22, 1909, in the same kind of soil, pure coarsely sifted kalmia peat. These plants grew to be the largest of any of the seedlings of 1908, their average height at the close of the season being 20.5 inches. The three plants shown in Plate IX, all over 24 inches in height and one of them 27 inches, were from this culture.

The use of pure peat was not advocated by the old heath growers. McNab recommended a mixture of 4 or 5 parts of peat, by bulk, to 1 of sand, and an even larger proportion of sand, 2 parts out of 5, has been recommended by Dawson for blueberries. When the pots are not plunged and do not therefore have the advantage of the superb aeration conditions found at the wall of the pot when surrounded by moist sand, it is probable that the presence of considerable sand in the soil is necessary to secure adequate aeration of the interior of the earth ball, for unless the pot is plunged most of the rootlets that lie against the sides of the pot will be killed and the plant must rely for its chief nourishment on the roots in the interior of the ball.

That the necessity for interior aeration in the pots is great in the case of heaths, if the plants are not plunged or are not frequently repotted, is shown by a peculiar and interesting cultural practice long tried and highly recommended by McNab. This practice is the distribution of broken crocks or pieces of sandstone through the soil at the time of repotting. He found by experience that the practice was highly advantageous to the plants, and although he did not directly explain his success in such a way, there is little doubt that

his method, which may be regarded as a substitute for plunging, w advantageous because it gave large aeration surfaces about the ston in the interior of the earth ball and provided a place there for a lar development of roots which could not take place at the wall of t pot. McNab's description of his method of repotting is as follows:

In shifting heaths I never reduce the old ball of earth more than by rubbl the sides and bottom with the hand, so as to loosen the outside fibers a litl I have often shifted heaths twice, and even three times, in the course of t spring and summer, with the greatest success. It is, however, quite unnecess to shift a heath until the young fibers have come through the fresh earth giv to it at its previous shifting, and begun to extend themselves round the inn edge of the pot or tub; but as soon as this takes place, they may then be shift with advantage. This frequent shifting, however, is quite unnecessary, unless be to encourage a favorite specimen; for in all ordinary cases, particulai when the plant is large, I consider one good shifting in two or three years qu sufficient. * * *

Besides the compost and draining which I have already mentioned, when begin to shift heaths I have always at hand a quantity of coarse, soft fr stone, broken into pieces, from an inch to 4 or 5 inches in diameter. Of the I always introduce a quantity among the fresh earth as it is put into the pot tub, round the old ball of earth about the plant, and press them well dov among fresh earth as it is put in. This I consider of great advantage to sorts of heaths, but more particularly so to those that may have been shift into a much larger pot or tub at once than what it had been grown in before, in what I would call biennial or triennial shifting. These pieces of stone m be put in as large as the opening will admit between the old ball and the ed of the pot. In some of our largest tubs this opening is full 4 inches wide, a where much earth is required to be put in the bottom over the draining befo the plant is put in, a quantity of these stones should be mixed with the ear also. I likewise use occasionally large pieces of soft burnt broken pots, p among the earth in the same way as the stones: but I prefer stones when I c procure them soft and free of iron. The quantity of stones which I introdu along with a large-sized heath at shifting, will, in most cases, if broken dow into sand, and added to the sand previously in the soil, form about one-thi part of the whole mass. When stones are introduced among the earth in t way I have recommended, heaths will never suffer so much in the summer fro occasional neglect to water them as they would do if the stones were not intr duced, because these stones retain the moisture longer than the earth, and the winter they allow a freer circulation of any superabundant moisture whi may be given through the mass.

The effect of the half shade used over the blueberries during t summer of 1909 was to make the growth of the plants continuo instead of confining it to a brief period in the early part of the seaso In a wild state the twigs of blueberry plants stop growing in earl summer, the stoppage being indicated by the withering of the uppe most leaf rudiment. The less vigorous twigs stop first, the mo vigorous ones next, and the shoots last. Stoppage of growth is has tened by hot dry weather and is deferred by cloudy humid weathe In the latitude of Washington stoppage of ordinary twig growth i wild plants of *Vaccinium atrococcum* begins in May and is usual

LARGE ONE-YEAR-OLD SEEDLINGS OF THE SWAMP BLUEBERRY.

All three plants, grown in pure kalmia peat, are over 24 inches high, the one at the left 27 inches. The middle plant has been pruned. Standing on the middle pot [illegible]

completed, except on vigorous shoots, in June. In some of the cultivated plants which were not shaded growth was similarly stopped by the advent of hot weather. In the plants under the slat shades, however, vigorous stems did not wither their tips until their normal growth had run its course, and as new shoots were continually starting there was no general stoppage of growth until September, and many of the plants continued to grow throughout that month.

The shade was not great enough to "draw" the plants; that is, to make their growth spindling through a stretching up for light. It was merely sufficient to prevent excessive heat and destructive transpiration.

(30) THE FLOWERING BUDS OF THE BLUEBERRY ARE PRODUCED BY THE TRANSFORMATION OF DORMANT LEAF BUDS IN THE LATTER PART OF THE SEASON.

The flowers and leaves of the swamp blueberry are produced in the spring from separate buds, and these buds are formed in the preceding year. The two kinds of buds are conspicuously different, as may be seen by the accompanying illustration. (Pl. X, fig. 1.) The leaf buds occupy the lower part of the twig. They are small, conical, about 0.08 to 0.12 of an inch (2 to 3 mm.) long, with 2 to 4 external scales about equaling each other in length and each ending in a sharp point. The points only of the interior scales, which are of similar length, are visible. When a leaf bud develops in the spring it produces a leafy twig.

The flowering buds are borne along the upper part of the twig. They are fat, ovoid structures, commonly 0.15 to 0.3 of an inch (3.5 to 7 mm.) long, several times larger than the leaf buds. They show ordinarily 10 to 15 external, broad, overlapping scales. Each flowering bud contains the rudiments of a raceme of usually 7 to 12 flowers, the bud of each of these flowers lying in the axil of a bract and bearing two bractlets below the middle of its short pedicel. When a flowering bud develops it produces a raceme of flowers, but no accompanying twig or leaves.

Leaf buds are always axillary and flowering buds almost always so. The bud at the summit of a twig is in reality situated in the axil of the uppermost leaf, except in the rare cases in which the twig tip does not wither when it stops its growth. In such cases a true terminal bud is formed, surrounded by a group of lateral buds in the axils of bracts. So far as observed these buds are always flowering buds and are produced on the ends of vigorous shoots.

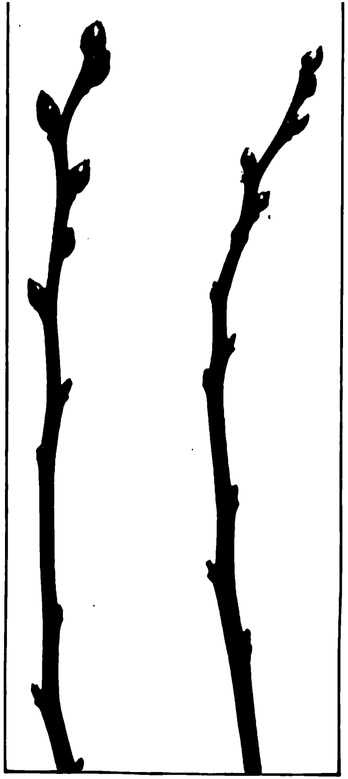
The manner in which the plants lay down their flowering buds, through the transformation of leaf buds, is very interesting, and it may prove to have a bearing of some importance on the method and time of pruning the bushes. The form of the leaf buds has already been described. They appear singly in the axils of the leaves almost

as soon as the leaf is fully developed. After a few weeks the external scales of the bud turn brown and the bud then goes into a condition of dormancy, unless it is forced into growth through an injury to the twig or some other unusual circumstance. In most of the buds this dormant condition continues through the summer, fall, and winter. If the plant is in condition to lay down flowering buds, however, a new sort of activity appears in the late summer or autumn. One or more of the leaf buds near the end of a twig start to grow. The two brown scales are spread apart, new green scales appear between them, and a large, fat, flowering bud is formed. The bud does not, however, continue its growth at this time, but its green new scales turn brown and the condition of dormancy is again resumed before cold weather comes on.

The flowering buds thus develop out of buds which are in no way distinguishable from leaf buds. They are, in fact, leaf buds until their transformation takes place, and except for such transformation they would remain leaf buds. Furthermore, it has been found experimentally that after the formation of flowering buds has been completed, leaf buds still lower on the twig can be forced by suitable treatment to transform themselves into flowering buds. Such an experiment was made, as follows:

On August 24, 1909, at Lanham, Md., a vigorous bush of *Vaccinium atrococcum* was selected, which had already laid down its flowering buds for the succeeding year. Two branches of nearly equal size, about 16 inches long, one with 14 twigs and 53 flowering buds, the other with 16 twigs and 48 flowering buds, were chosen for the experiment. On the branch containing the 48 flowering buds each twig was cut off at a point between its lowermost flowering bud and its uppermost leaf bud, with the object of ascertaining whether any of the leaf buds on the stub of the twig would transform themselves into flowering buds. The other branch was left unpruned as a check, to show whether the normal laying down of flower buds had in reality been completed on August 24. On October 1, 1909, the two twigs were again examined. The pruned branch had laid down 31 new flowering buds, which in all cases were the transformed upper leaf buds on the stubs of the twigs. On the check branch only 1 new flowering bud had been laid down.

The best method of pruning the swamp blueberry is yet to be devised, but if a superficial pruning, like that of a hedge, proves to be a good method of stimulating vigorous growth, it is evident from this experiment that the most advantageous time to do the pruning, if a crop is to be secured the next year, is after the berries are gathered and about the time when the bush is forming its next year's flowering buds. It will then lay down new flowering buds on the cut stubs. If the pruning were done in late autumn, in the winter,



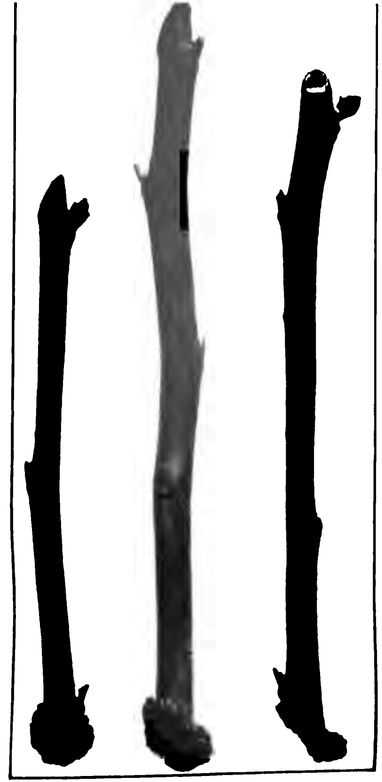


FIG. 1.—FLOWERING BUDS AND LEAF BUDS ON BLUEBERRY TWIGS.

FIG. 2.—FLOWERING BUDS ON A BLUEBERRY CUTTING.

FIG. 3. FLOWERING BUDS ON BLUEBERRY CUTTINGS.

Each twig in figure 1 shows six flowering buds. The twigs were photographed in March from plants that were 1 year old when the buds were laid down. The middle [illegible] bud into a flowering bud. (All natural size.)

or in the spring, no new flowering buds would be formed to replace those removed by the pruning.

The time of laying down flowering buds seems to be correlated with the length of the growing season. About Washington *Vaccinium atrococcum* begins to form its flowering buds in the latter part of August, one to two months after its berries are matured. In *Vaccinium pallidum*, on the high mountain summits of North Carolina, where the growing season is short, the transformation of leaf buds into flowering buds begins as early as the last week in July while some of the berries are still green. In the cultivated plants at Washington the formation of flowering buds did not begin in 1909 until September, and it continued on somè plants until cold weather stopped their growth.

The laying down of flowering buds appears to be a phenomenon local within the twig. Cuttings of the swamp blueberry made in New Hampshire on July 9, 1909, transformed their leaf buds into flowering buds in the cutting bed after reaching Washington, as shown in Plate X, figure 2, but whether the transformation in this case was made before or after the cutting had rooted was not observed. In another case, however, that of cuttings made in New Hampshire September 11, 1909, from long late shoots bearing only leaf buds, the transformation into flowering buds began to occur in the cutting bed October 12 and was completed before any roots had formed. (See Pl. X, fig. 3.)

(31) AT THE END OF THEIR FIRST YEAR SEVENTY PER CENT OF THE BLUEBERRY PLANTS HAD LAID DOWN FLOWERING BUDS FOR THE NEXT SPRING'S BLOSSOMING.

At the end of the season of 1909, 177, or 70 per cent, of the 250 seedlings of 1908 that had been put in 6-inch pots had developed flowering buds. In Plate XI is shown one of these seedlings, photographed on November 2, 1909, which had laid down 42 flowering buds. One plant produced 58 flowering buds. At the end of the preceding season, 1908, at least 25 per cent of the seedlings of 1907 that were still kept in pots had produced flowering buds. Therefore, notwithstanding the statements of earlier experimenters that the seedlings of this species do not fruit until they are several years old (p. 68), it is regarded as established that under the culture system worked out by these experiments a substantial percentage will lay down flowering buds at the end of the first year and will bear fruit the second year.

Attention has already been called (p. 67) to the occasional laying down of flowering buds when the seedlings were only 7 months old, followed rarely by flowering and fruiting at the age of less than a year.

(32) **Plants of the swamp blueberry are exceedingly hardy and pass the winter in good condition outdoors when the soil is covered merely with an oak-leaf mulch, but when not exposed to outdoor conditions they do not begin their growth in spring in a normal manner.**

During the fall, winter, and early spring of 1908–9 a series of blueberry seedlings of 1907 was kept outdoors on a south window sill to ascertain whether repeated freezing and thawing would kill them. Most of the plants were in thin glass 3-inch pots, covered at the sides with one thickness of gray blotting paper. One plant (to which reference is again made on pp. 75 and 76) was in a 5-inch earthen pot. None of the plants were mulched or covered in any way. They were watered whenever necessary to keep the soil from drying. In cold weather the air circulated freely about the pots and the soil was repeatedly frozen solid. On warm, sunny days the melting of the ice took place rapidly. Hard freezing followed by quick thawing was many times repeated, and the conditions of exposure were such that the plants undoubtedly were subjected to a severer test for hardiness than they would ever receive under cultural conditions.

The plants passed the winter without losing any of their twigs. The wood was plump and in excellent condition when spring came, as was evidenced further by the remarkable uniformity with which every dormant bud started to grow after the first few warm days.

For the roots of some of the plants in glass pots, however, the exposure was too severe. In some of the glass pots no root growth followed the starting of the twigs, and the plants finally died. In others the root growth at first was feeble and the plants lost some of their newly started twigs by withering. Most of the plants, however, including the one in the 5-inch earthen pot, made normal growth of both twigs and roots, notwithstanding the extraordinarily severe treatment to which they had been subjected. No difficulty is anticipated, therefore, in wintering blueberry plants successfully out of doors under any ordinary cultural conditions. The seedlings of 1908 covered with oak leaves in their outdoor plunging bed of sand passed the winter of 1909–10 in good condition.

That blueberry plants must be subjected to some sort of exposure, if they are to start satisfactorily in the spring, is indicated by the behavior of certain seedlings of 1907 which were carried through the winter of 1908–9 in a rose house, where the temperature at night was about 60° F. and during the day about 10 degrees higher. These plants, although subjected to most persistent coaxing, absolutely refused to grow during the the five months from November to March, although newly germinated seedlings grew luxuriantly under exactly the same conditions.

The comparison of these indoor plants with outdoor plants may best be made by an examination of the buds shown in the accompany-

YEARLING BLUEBERRY PLANT WITH FORTY-TWO FLOWERING BUDS.

(One-fourth natural size.)

ing illustrations, made from typical indoor and outdoor specimens. The photographs reproduced in Plate XII were made on March 27, 1909. The plant shown in figure 1 of this plate was a seedling of September, 1907, which had been kept in a greenhouse all its life at a temperature suited to the growing of roses. The plant shown in Plate XII, figure 2, was identical in history with the other until October 20, 1908, when it was placed outdoors and exposed to the severest winter conditions. It was one of the window-sill plants described on page 74. The leaves shown on the indoor plant (Pl. XII, fig. 1) are those formed in the summer of 1908, which by reason of the warm temperature of the greenhouse in which the plant was wintered had never fallen off, although the plant had made no growth later than October, 1908. Neither a flowering bud nor a leaf bud has started on this plant. On the outdoor plant (Pl. XII, fig. 2) the 4 flowering buds and 62 leaf buds which had lain dormant during the winter had begun to push a few days before the picture was taken.

Plate XIII, from photographs taken on April 24, 1909, shows the same two plants nearly a month later. The leaf buds on the outdoor plant (Pl. XIII, fig. 2) have grown into leafy twigs and the flowering buds are fully opened. Of the dormant buds on the indoor plant (Pl. XIII, fig. 1) only two have started to grow. Of these two new twigs, one on the stem to the left, in the axil of the third leaf from the top, has withered its tip and stopped developing before making a full-sized leaf. The other new twig, on the stem to the right, developed abnormally from the axil of a basal bract of a flowering bud. It later made good growth and became a very vigorous shoot. All the flowering buds on this plant dried up and produced no flowers.

The erratic starting of dormant plants which have not been subjected to the conditions necessary to bring them out of their dormancy in a normal manner is well shown also in Plate XIV. This illustration is from a photograph taken February 18, 1909. The plant was a seedling of September, 1907, which was brought into the greenhouse in early December, 1908, and remained there during the winter. The illustration shows that only one of the two flowering buds on the upper twig has started, one of the four on the lower twig, and none of the leaf buds.

There can be no question that for ordinary purposes blueberry plants should be wintered outdoors. If it is desired in experimental work to force blueberry plants to fruit in a greenhouse during their second winter, it will be necessary either to etherize them or to find out some other method of treatment by which the starch in their twigs can be transformed into other carbohydrates available for the building up of new plant tissues. The writer believes that in the

hard-wooded deciduous-leaved trees and shrubs of cold countries this transformation of starch will be found to be caused normally by the changes, probably enzymatic, that follow exposure to an alternation of high and low temperatures rather than exposure to a single low temperature.

(33) DORMANT PLANTS MAKE THEIR EARLY SPRING TWIG GROWTH BEFORE NEW ROOTS BEGIN TO DEVELOP

The root growth of blueberry plants in early spring is very sluggish, in strong contrast to the activity of their stems. In the plant illustrated in Plate XIII, figure 2, no new root growth had taken place up to the time the photograph was made. For their early spring growth blueberry plants seem to depend on the food stored in their twigs the year before. A microscopical examination has shown that the pith and medullary rays of winter twigs are gorged with starch.

It may be of interest to state here, as bearing on the difficulty of making stem growth exhibited by an improperly wintered blueberry, that the indoor plant shown in figure 1 of Plates XII and XIII had made considerable new root growth at the stage shown in Plate XII and abundant root growth in Plate XIII. The starting of dormant buds appears from this and many other similar cases not to be influenced by the presence or absence of new root growth.

A practical suggestion based on the late spring root development of the blueberry is that transplanting may perhaps be done up to the time of flowering with little injury to the plant.

(34) UNLESS POLLINATED BY AN OUTSIDE AGENCY, SUCH AS INSECTS, THE FLOWERS PRODUCE LITTLE OR NO FRUIT.

Many blueberry plants, from seed germinated in September, 1907, were brought into flower in one of the Department greenhouses during the winter of 1908–9. When left to themselves the flowers rarely produced fruit. The greenhouse contained few pollen-carrying insects, a few ants and flies merely, no bees. It was found that the flowers were so constructed as to be unable ordinarily to pollinate themselves. The lack of fruit was evidently due to lack of pollination. When pollinated artificially the flowers usually produced fruit.

In its natural position the flower (fig. 27) is not erect but inverted, the narrow orifice of the corolla being lowermost, the nectar welling up from the surface of the disk between the base of the style and the base of the filaments. The ten stamens and the style hang downward within the corolla, the stamens being shorter than the style. The pollen when mature drops down from the two anther sacs through the two anther tubes which the stamens of these plants possess and out at the terminal pores. (See fig. 28.)

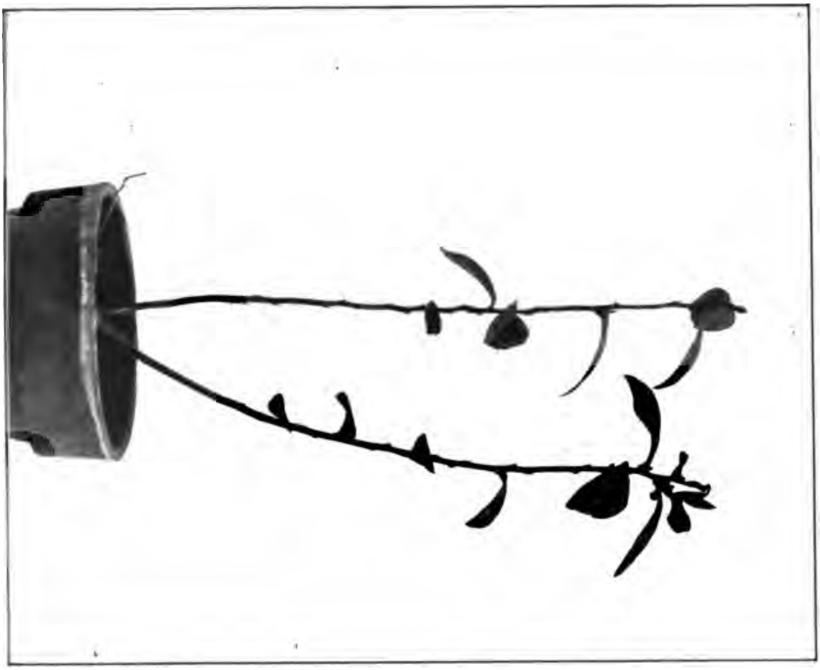


FIG. 1.—BLUEBERRY PLANT WHICH WAS WINTERED INDOORS BEGINNING GROWTH IN THE SPRING.

(Photographed March [illegible]; one-fourth natural size.)

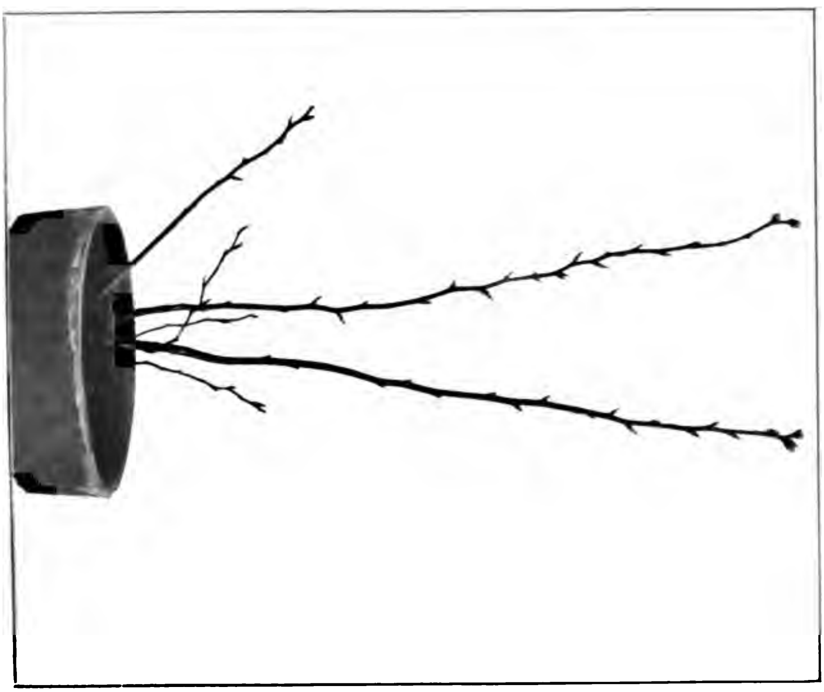


FIG. 2.—BLUEBERRY PLANT WHICH WAS WINTERED OUTDOORS BEGINNING GROWTH IN THE SPRING.

(Photographed March 27; one-fourth natural size.)

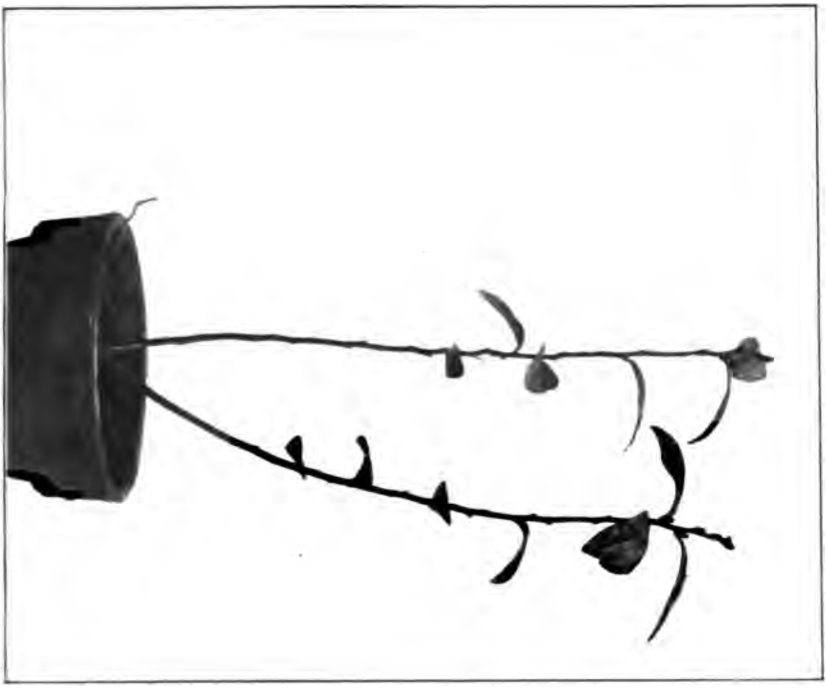


FIG. 1.—BLUEBERRY PLANT WHICH WAS WINTERED INDOORS CONTINUING GROWTH IN THE SPRING.

FIG. 2.—BLUEBERRY PLANT WHICH WAS WINTERED OUTDOORS CONTINUING GROWTH IN THE SPRING.

The operation of the mechanism for releasing the pollen may be observed with a high-power hand lens. The stamens hang in a close circle about the style. The filaments are broad and laced into a tight tube by the interweaving of their marginal hairs, the anther sacs press close together, and therefore the only convenient way of access to the nectar is through the slits between the anther tubes. The anther tubes are stiff and when one of them is pushed to one side the movement is communicated to the anther sac. The pollen if mature is dislodged and falls down the tube and out at the orifice.

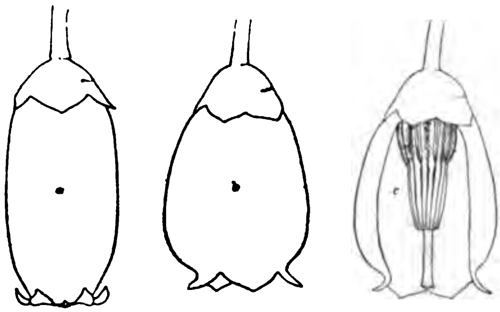


FIG. 27.—Flowers of the blueberry, from 1908 seedlings of the large-berried New Hampshire bush of *Vaccinium corymbosum: a,* Flower of the *corymbosum* type of plant; *b,* flower of the *amoenum* type of plant; *c,* same as *b,* but part of the corolla removed to show the stamens, style, and stigma. (Enlarged 3 diameters.)

The pollen does not come out of the anthers readily on a cloudy, humid day, but on a warm, sunny, dry day it accumulates in the tubes and when they are moved it runs out like grain from a grain chute. The pollen grains (fig. 29) do not stick to the sides of the parchment-like anther tubes when these are dry, but they have the faculty of adhering to hard surfaces, such as glass or the lead of a lead pencil, and they doubtless would adhere also to the hard shell of an insect whether it was covered with hairs or not.

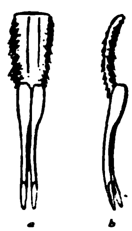


FIG. 28.—Stamens of the blueberry, from the flower shown in fig. 27, *c*: *a,* View from the inner face; *b,* side view. Both views show the broad filament with hairy margins and the anther sacs, tubes, and pores. (Enlarged 5 diameters.)

The pores of the anther tubes do not open squarely across the ends of the tubes, but they are set on a long bevel facing inward. The pollen when released would therefore fall upon the stigma were it not for a peculiarity in the structure of that organ. The sticky stigmatic surface, which the pollen must reach to effect pollination, is at the apex of the globular or top-shaped stigma, while the sides of the stigma as far up as the middle have a dry surface ending in a short collar a little wider, during the early maturity of the stigma, than the widest part of the stigmatic surface. (See fig. 30.) In the inverted position of the flower the falling pollen strikes this dry

surface, like the outside of an inverted funnel, and drops off the rim or remains on it, without reaching the stigmatic surface which lies protected beneath.

Ordinarily pollination is effected by some insect which, pushing into the orifice of the corolla from beneath in search of nectar, releases the pollen, as already described. In continuing its quest for nectar the insect brushes against the stigma with some portion of its body, which is covered with pollen, either from the same flower or from some other flower previously visited.

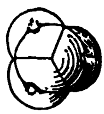


FIG. 29.—Compound pollen grain of the blueberry, consisting of four simple grains permanently cohering. (Enlarged 200 diameters.)

In pollinating the flowers by hand it was found impracticable to collect sufficient pollen to apply with a brush. The following simple and convenient method of pollination was devised: A wide opening was torn in a corolla with a pair of forceps, so that the stamens and stigma could be approached from the side. Then the lead of a lead pencil, flattened on one side and held horizontally, was brought up against the open ends of the anther tubes from below. A portion of the falling pollen was caught on the flat lead, where it could be seen easily because of the blackness of the background. Pollination was then completed by touching the stigmatic surface gently two or three times with the pollen-laden lead. A pollinated flower may be marked readily by pinching off with forceps one or more of the calyx lobes. Fruit was produced from flowers pollinated either with their own pollen or with pollen from another flower.

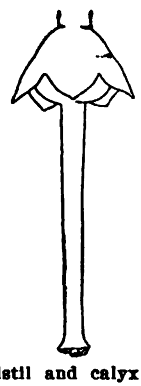


FIG. 30.—Pistil and calyx of the blueberry, showing the style and stigma. (Enlarged 5 diameters.)

The self-pollination of a blueberry flower, without insect aid, appears to occur, but only occasionally. On greenhouse plants fruit is rarely produced when the flowers are not artificially pollinated, and the same is true of outdoor plants protected from insects by a covering of gauze. The conditions of these observations were not such as to obviate all possibility of the accidental visit of some insect, but it is believed that real self-pollination occurred in some cases.

(35) THE FRUIT MATURES ABOUT TWO MONTHS AFTER THE FLOWERING.

A few days after pollination the corolla, with the stamens, falls off. The stigma at this time has turned brown, and within a day or

IRREGULAR FLOWERING OF A BLUEBERRY PLANT WINTERED INDOORS.
[illegible]

two the style also falls. The calyx remains permanently attached to the ovary and berry. About a week after the opening of the corolla, the ovary, which at first was much narrower than the expanded calyx, begins to swell and grow. This growth continues for about a month, and then for about another month the green berry makes little increase in size. A few days before the time of ripening the calyx turns purplish, next the green color of the berry takes on a translucent appearance, the next day it turns to a light purple, and the following day to a dark purple or whatever its permanent color may be. During these few days the berry makes a very rapid growth, its diameter often increasing 50 per cent. After reaching its permanent color the berry changes little in size, but for several days continues to improve in sweetness and flavor.

It is a characteristic of blueberries, important from the standpoint of picking, that after ripening they will remain on the bush a long time, often a month or more, without losing their plumpness or their flavor. This makes possible the removal of all the berries from a bush at one clean picking, unless to catch a fancy market a partial early picking is desired.

It is of interest to record that although the largest berry observed on the parent bush of the seedlings of September, 1907, was 0.46 of an inch in diameter, a berry ripened in the greenhouse on one of these seedlings measured on April 24, 1909 (Pl. XV), 0.49 of an inch in diameter, and August 2, 1909, one of the same seedlings had a ripe berry 0.5 of an inch in diameter.

(36) SO FAR AS OBSERVED THE SWAMP BLUEBERRY WHEN GROWN IN ACID SOILS IS LITTLE SUBJECT TO FUNGOUS DISEASES OR INSECT PESTS.

Like all plants grown in greenhouses, blueberry seedlings need to be watched in order to detect and stop promptly any fungous or insect pests that may appear.

With the exception of the Asterocystis-like root fungus described on page 65 as occurring on sickly plants in alkaline soils, the only parasitic fungus found on any of the plants was a mildew identified by Mrs. Flora W. Patterson as *Microsphaera alni vaccinii*, which appeared sparingly when the atmosphere of the greenhouse was too moist. This mildew is abundant on *Vaccinium vacillans*, both wild and cultivated, but the swamp blueberry is very little subject to its attacks, an important characteristic. This fungus would doubtless respond readily to the ordinary treatment for mildew with pulverized sulphur.

Among insects a green aphis sometimes threatened to damage the growing twigs, but it was easily destroyed by tobacco fumigation.

The greenhouse red spider (*Tetranychus bimaculatus*) infested some of the cultures, especially in the warmer greenhouses, occurring chiefly on the backs of the leaves, and seriously injured the plants

unless promptly checked. The most satisfactory treatment was to syringe the plants once or more a day with a swift spray of water, repeating the treatment until the animals were cleared off.

A pathological condition observed in the summers of both 1908 and 1909, at first supposed to be physiological in cause, has now been traced to an insect. The young leaves of tender shoots become semitransparent or "watery" in appearance, remain small, develop a faintly rusty color on the lower surface, tend to become slightly cockled, and sometimes turn brown and wither. It was finally observed that these leaves were infested with a very minute animal, much smaller than a red spider and when not in motion difficult to distinguish with a strong hand lens. Specimens submitted to Mr. Nathan Banks, of the Bureau of Entomology, were identified by him as a mite of the genus Tarsonemus and belonging probably to an undescribed species.

A similar and perhaps identical mite had done considerable damage to young seedlings in the greenhouse during the winter of 1908–9, its presence being indicated by the conspicuous cockling of the leaves. The difficulty had then been met by the pruning of the affected twigs. It was observed, however, in the summer of 1909 that the mite producing the watery appearance of the leaves did not occur on outdoor plants fully exposed to rain and dew, but only on plants partly or wholly protected by glass. It is suggested, therefore, that frequent syringing with water may be the proper means to control this mite.

On the whole, this species of blueberry when properly grown may be regarded as unusually free from the depredations of fungi and insects.

IMPROVEMENT AND PROPAGATION.

(37) THE PARENT PLANT OF THE SWAMP BLUEBERRY SEEDLINGS, THE CULTURE OF WHICH HAS BEEN DESCRIBED, BORE BERRIES OVER HALF AN INCH IN DIAMETER.

The parent of the blueberry seedlings of 1908 was a bush of *Vaccinium corymbosum* selected at Greenfield, N. H., in July, 1908, after three summers of cursory observation in the mountains of southern New Hampshire and three weeks of diligent search in the summer of 1908. The bush grew at an elevation of 950 feet above the sea. It stood with many other blueberry bushes in an old, brushy, mountain pasture, in permanently moist but not swampy soil. It was about 7 feet in height, and the largest of the several stems was about 2 inches in diameter. The plant was old and somewhat decrepit, the tops on some of the stems being partially dead. Some parts of the bush, however, were in full vigor, with robust foliage and twigs. The leaves were dark green above and pale glaucous green beneath, with entire margins, and smooth on both sides except for a slight pubescence on the midrib and principal

BERRY RIPENED ON A BLUEBERRY SEEDLING AT THE AGE OF NINETEEN MONTHS.

(Natural size.)

veins of the upper surface. They were of large size, on the fruiting twigs reaching a length of 2 inches and a breadth of 1 inch and on vigorous shoots having the corresponding measurements 2.5 and 1.5 inches. The character of the leaves is mentioned in detail because of the remarkable variation shown in the leaves of the seedlings, particularly in size, toothing, color, and pubescence. The large flowers produced in the spring of 1909 were 0.4 of an inch (10 mm.) long from the base of the ovary to the tip of the corolla; the sepals were very short, and the corolla white and nearly cylindrical.

The berries were of large size, reaching a diameter of over half an inch. The color was an unusually pale blue, due to a dense bloom or glaucousness over the nearly black surface. In form the berry was not spherical, but somewhat depressed or tomato shaped. The calyx in the ripe berry (Pl. VI, fig. 1) was almost obliterated, because it was small in the beginning and because of lateral stretching of the berry in acquiring its depressed form. This smallness of calyx is of importance, because in such a berry no shelter is afforded beneath the sepals for insects, and also because the amount of "rag," or indigestible skin, is much less than in a berry with a large calyx. In flavor the berry was exceptionally good. It was sufficiently acid to be decidedly superior to the mild, sweet berry of *Vaccinium pennsylvanicum*, yet not sour like the berry of *V. canadense*. It represents one of the best types of flavor in the variable *V. corymbosum*.

The only unfavorable feature of this bush was the lateness in the maturity of its berries, a characteristic of the species to which it belongs. The earliest New England berries, which bring the fancy wholesale price of 20 cents or more per quart for the first few days, as described on page 12, are those of the dwarf *Vaccinium pennsylvanicum*, which mature about two weeks earlier than those of *V. corymbosum*.

The size of the berry is of such importance as to warrant an exact record of the measurement, not only of the largest berries but of all the berries from an average picking. On August 2, 1908, an average pint of berries was taken out of a clean picking of this bush and each berry was measured. The measuring was done by means of a metal plate containing a series of circular holes 5, 6, 7 mm., etc., in diameter. The pint of berries showed the following sizes:

Diameter of berry.	Number of berries.
7 to 8 mm	2
8 to 9 mm	50
9 to 10 mm	191
10 to 11 mm	278
11 to 12 mm	137
12 to 13 mm	10
13 to 14 mm	3
	671

The largest berry measured on this bush was 14.02 mm. (0.552 of an inch) in diameter.

Three quarts of berries were picked from the bush; all those less than 10 mm. in diameter were discarded, and the remainder, about 2 quarts, were carried to Washington for seed purposes.

(38) THERE IS EVERY REASON TO BELIEVE THAT THE BLUEBERRY CAN BE IMPROVED BY BREEDING AND BY SELECTION.

The swamp blueberry (*Vaccinium corymbosum*) is an exceedingly variable bush. There are three especially well-marked forms, called *V. amoenum*, *V. atrococcum*, and *V. pallidum*, by some authors regarded as distinct species, by others as forms of *V. corymbosum*. Within the limits of these forms variation is also extensive. There is great opportunity for selection among wild varieties in the size, color, flavor, and time of ripening of the berries and in the productiveness and vigor of the bushes.

That types possessing desirable qualities can be crossed there is no question. A method of pollination has already been described (see p. 78), which, supplemented by the removal of the stamens on the female parent before they have matured their pollen and also by the protection of the pollinated flowers from insects, would insure a genuine cross.

The possibility of securing valuable varieties is accentuated by the marked variation observed in the character of the offspring of the large-berried bush from which the seedlings of 1908 were grown. Besides minor variations, these seedlings show three forms which may be regarded as types. One of these, characterized by its low stature and leaves tending to be conduplicate and by its long persistence into the winter in a green state, is perhaps the result of some pathological difficulty. Two of the types, however, appear in every way to be normal. One has its leaves large, obovate-elliptical, glaucous on the back, and with entire margins, such as are possessed by the parent and are typical of true *Vaccinium corymbosum*, and it develops only a few though very robust stems, with few flowering buds. The other has smaller, narrower leaves, green on both surfaces, and with margins closely and evenly serrulate. It produces many stems smaller than those of the other, and more numerous flowering buds. It is strongly suggestive of the plant called *Vaccinium amoenum*. It is much larger and more robust than *V. pennsylvanicum*, and may possibly be a hybrid between that species and *V. corymbosum*.

The characters of bush and foliage in these two types have not yet been correlated with any differences they may show in flower and fruit. It is, however, of great interest that these same two types occur among the seedlings of 1907, as well as those of 1908, which came from a different though similar bush growing about 2 miles from the other.

(30) THE SWAMP BLUEBERRY HAS BEEN PROPAGATED BY GRAFTING, BY BUDDING, BY LAYERING, BY TWIG CUTTINGS, AND BY ROOT CUTTINGS.

On March 2, 1909, a few scions of the large-berried bush from New Hampshire, dormant winter twigs, were grafted on seedlings of 1907 which had been started into growth in the greenhouse. The actual work of grafting was done by Mr. Edward Goucher. All were simple splice grafts, the diagonal cut being about 0.75 of an inch in length, the diameter of stock and scion at the point of contact about 0.15 of an inch, and the length of the scion about 2.5 inches after it was cut off at the tip just below the lowest flowering bud. The splice was wrapped tightly and completely with raffia, but no wax was applied except to the cut tip of the scion. In order to prevent a possible injurious degree of evaporation from the scion, the whole graft, which was near the base of the plant, was surrounded nearly to the tip of the scion with a loose mass of sphagnum, which was kept slightly moist though well aerated.

All the scions put out new growth from their buds in about ten days. In half the grafts union did not take place, the new growth finally collapsed, and the scion died. In the others the surfaces united satisfactorily and the wrapping was removed. By the end of the season of 1909 the grafts had made a growth of 5 to 8 inches and had laid down flowering buds. (See Pl. XVI, fig. 1.)

The first experiments in budding were begun on August 13, 1909, the work being done by Mr. Henry H. Boyle. Seven seedlings of 1906 and 1907 were budded with summer leaf buds of the large-berried *Vaccinium corymbosum* bush from New Hampshire. On August 16, 6 other seedlings of 1906 and 1907 were budded with buds from large-berried plants of *V. pallidum* from North Carolina. On September 2 and 3, 1909, 26 more seedlings, of 1907 and 1908, were budded with buds from the New Hampshire bush. The buds were inserted near the base of the plant on stems 0.25 to 0.5 of an inch in diameter. The method of procedure was that used in ordinary budding, as of peaches, the same T-shaped cut being made in the bark of the stock, the bud wood cut to the length of half an inch or a little more, and the bud after insertion wrapped tightly with raffia.

The percentage of success in the budding was small. Out of the 39 plants budded only 16 retained their bud alive and in apparently good condition at the end of the season, and the following spring only 5 were alive and in condition to grow. Plate XVI, figure 2, is a reproduction of a photograph of one of the successful buds from the large-berried New Hampshire bush, taken in the winter of 1909–10 after union had taken place, the wrapping had been removed, and the stock had been cut off above the bud.

Comments on some of the features of these budding experiments may be useful to other experimenters. The growth of the stems

during the portion of the season remaining after the budding wa sufficient to strain the wrappings and, unless the bud wood was hel tightly for its whole length, to push the bud out of place. It wa found best to leave the bud tightly wrapped to the end of the seas notwithstanding the fact that the stock might become deeply creas and choked.

An examination of the buds that failed showed that in most ca bark or callus from the stock had intruded between the stock w and the bud wood, sometimes covering the entire surface. Wh the bud wood in some such cases was in part still alive and green was of course doomed.

As late as August 30 in New Hampshire, and September 3 Massachusetts, bushes of the swamp blueberry were found in which bark would peel and buds could be inserted. On September 2 no w bushes of *Vaccinium atrococcum* could be found at Washington condition to bud. Even in Massachusetts and New Hampshire, the dates mentioned, most of the bark on all the bushes and all o on many bushes would not peel. Bark still in good condition curred mostly on vigorous shoots of the season and in some cases the preceding season. Sometimes the bark on the north side of erect shoot would peel when that on the south side would not. B still green and whole would peel when near-by bark which from and exposure had begun to turn brown and split on the surface wo not peel.

Propagation by layering was carried on in 1908 and 1909. the greenhouse experiments moist live sphagnum proved to be a m successful material than peat and sand in which to root a laye branch. When the branch laid down was one which was harden its wood but still bearing leaves, it callused and rooted readily in sphagnum at the point where the bark was sliced, but when a you soft-wooded branch was used it usually began to decay at the and finally died. Although several times tried it was never fo practicable to sever a layered and rooted branch from the pare plant successfully except at the period of winter dormancy after t leaves had been shed.

(40) THE MOST DESIRABLE METHOD OF PROPAGATING THE SWAMP BLUEBERRY IS CUTTINGS.

While the surest method of propagating a selected blueberry bu is by layering, and the most rapid method of securing fruiting plat from it is by grafting, both these methods have certain objectio which do not apply to the method of propagation by cuttings.

Propagation by grafting is objectionable because of the habit t blueberry plant has of continually sending up new shoots to repla the old stems. These shoots come from the root or from the base

FIG. 1.—GRAFTED BLUEBERRY.

FIG. 2.—BLUEBERRY SEEDLING SUCCESSFULLY BUDDED.

The line of union between the stock and the scion in figure 1 is clearly shown. Two twigs had grown from the scion, a short one near the tip and a vigorous one from the lower part. In figure 2 is shown an inserted bud which has united successfully with the stock, but has not yet begun to grow. The inset figure is about three times natural size. The two main figures are natural size.

the stem just below the surface of the ground. Originating below the graft they would not bear fruit of the variety desired, and such a grafted plant would always be liable to serious depreciation in value. It is suggested, however, for the benefit of any who may desire to follow up this method of propagation, that a plant produced by root grafting would be somewhat less liable than a stem graft to the production of shoots from the stock.

Propagation by layering is not open to the objection just raised against propagation by grafting. The difficulty with layering is that only a few plants can be propagated from a parent in this way at one time. The method of layering is slow and therefore, from a commercial point of view, faulty.

Propagation by cuttings, whether of the root or the stem, is subject to neither of the objections raised to grafting and to layering. In a plant raised from a cutting the whole plant body, including the root, is of the variety desired, and alien shoots can never be produced. Furthermore, hundreds or even thousands of cuttings may be taken at one time from a valuable plant and a large stock of offspring can soon be accumulated.

The present objection to the propagation of the swamp blueberry by cuttings is the difficulty of making a high percentage of the cuttings grow. In this respect the experience of the last two years may be characterized as a series of frequent alternations of high hopes and disappointing failures. The intimate knowledge, however, acquired from these experiments regarding the behavior of cuttings under many different conditions gives ground for confidence in ultimate success; but as we are only in the middle of things in this matter a full description of the experiments with cuttings must be deferred until satisfactory results shall confirm our confidence in the methods used.

For the present it may suffice to show an illustration of a plant from a root cutting (fig. 31) and another of plants from twig cuttings (Pl. XVII) of the big-berried bush from Greenfield, N. H. In Plate XVIII is illustrated, from a photograph taken in the winter of 1909–10, a plant grown from a cutting taken on October 15, 1908, from a seedling of September, 1907. Although itself only a year old, and even then taken from a seedling only a year old, the plant after passing the winter of 1908–9 in the greenhouse and the summer of 1909 outdoors, had laid down 156 flowering buds at the time it was photographed.

While these cases show that swamp blueberry plants can be produced successfully from root cuttings and stem cuttings, the successes have been so erratically distributed that the recommendation of any particular method is hardly warranted at the present time.

It should be stated here that those species of blueberry which spread by rootstocks, such as *Vaccinium pennsylvanicum*, and other related plants having the same habit, like the deerberry (*Polycodium stamineum*) and the dwarf huckleberry (*Gaylussacia dumosa*), have

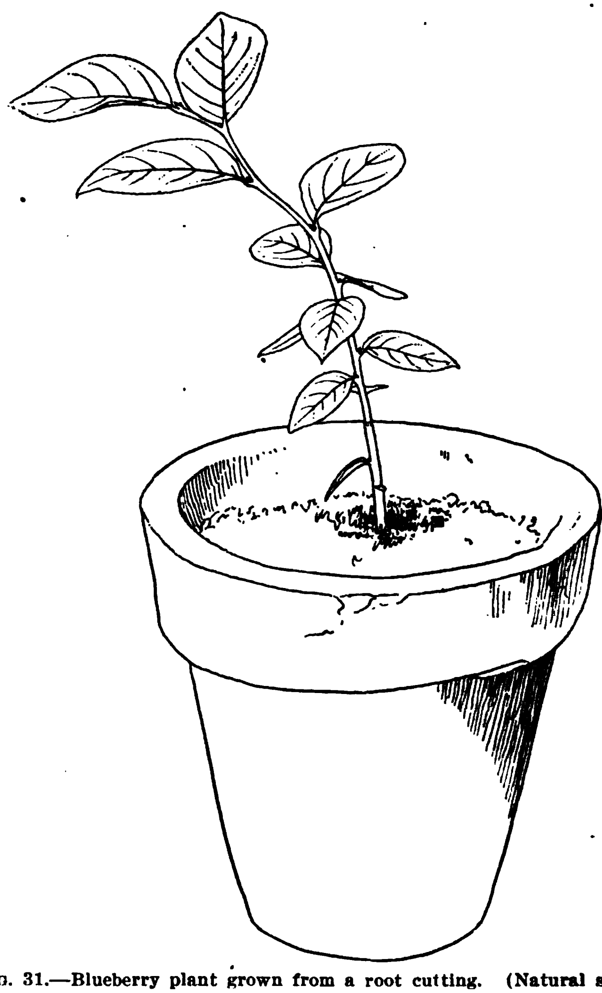


FIG. 31.—Blueberry plant grown from a root cutting. (Natural size.)

been reproduced without difficulty by rootstock cuttings. This method is not generally applicable to the swamp blueberry, however, as large plants of this species seldom produce rootstocks.

FIELD CULTURE.

(41) EXPERIMENTS HAVE BEEN BEGUN IN THE FIELD CULTURE OF THE SWAMP BLUEBERRY.

While the results of the pot culture experiments are regarded as highly successful and satisfactory, the experimental field plantings made in 1908 and 1909 can not be said to have given more than

BLUEBERRY PLANTS FROM TWIG CUTTINGS.

(One-half natural size.)

promising results. It is true that out of one planting of 179 seedlings of 1907 made in a partially moist natural meadow at Greenfield, N. H., in early July, 1908, 97 per cent outlived the severe drought of that summer and the rigors of the following winter, and 6 per cent flowered and set fruit. The plants were not observed during the ripening season. While this record of flowering and fruiting in plants 2 years of age may be regarded as satisfactory in comparison with the several years supposed by the earlier experimenters to be required before fruiting, it nevertheless can not be regarded as satisfactory in comparison with the pot cultures from the seedlings of 1908, of which, as stated on page 73, 70 per cent were prepared to flower in 1910, their second year.

While the results of the field experiments thus far made are regarded as in no wise approaching what may confidently and reasonably be expected, they nevertheless may serve even at this early stage to convey some useful lessons.

The field planting of 179 plants already referred to contained 84 plants which had never been potted but were torn apart out of their original seed flat while in full growth and set outdoors in the place indicated. These plants after such severe treatment never grew to be robust and none of them flowered. It was among them that all but two of the deaths in the field occurred. That any of the plants should survive such rough usage is of interest experimentally, but in actual practice such a method should never of course be followed.

Most of the field plantings were made in areas where the natural soil had been chopped with a mattock to the diameter of about 18 inches and the depth of about 8 inches immediately before the planting. It is evident from the comparison of certain plantings made in 1909 that a growing plant when set out in such freshly chopped soil receives a serious setback. On June 4, 1909, 216 seedlings of 1908 were set out in new holes prepared as described above, and 48 other seedlings of 1908 were used at the same time to replace dead or feeble plants set out in the preceding year. These 48 plants therefore went into soil that had rotted for a year, although it was in part penetrated again by new roots from the surrounding native vegetation. When next examined, on June 30, the two groups of plants showed the most marked difference in growth. The plants in the new holes showed the same purpling of the leaves and cessation of growth as did plants in the greenhouse when suffering from excessive acidity due to potting in raw peat. (See p. 60.) The plants in the old holes, on the contrary, were nearly all of good color and growing well. It is inferred from this observation that blueberry plants will do better if the holes in which they are set are

filled with peat or peat mixture the acidity of which has been tempered by several months of decomposition.

In all the field plantings thus far made the plants were set out while in full growth. Although most of them were in pots when transplanted, and therefore carried their entire root system with them, nevertheless it is regarded as highly probable that a better plan would be to set the plants out when dormant, in the early spring of their second year. Such a plan would offer several advantages which it is hardly necessary to recount.

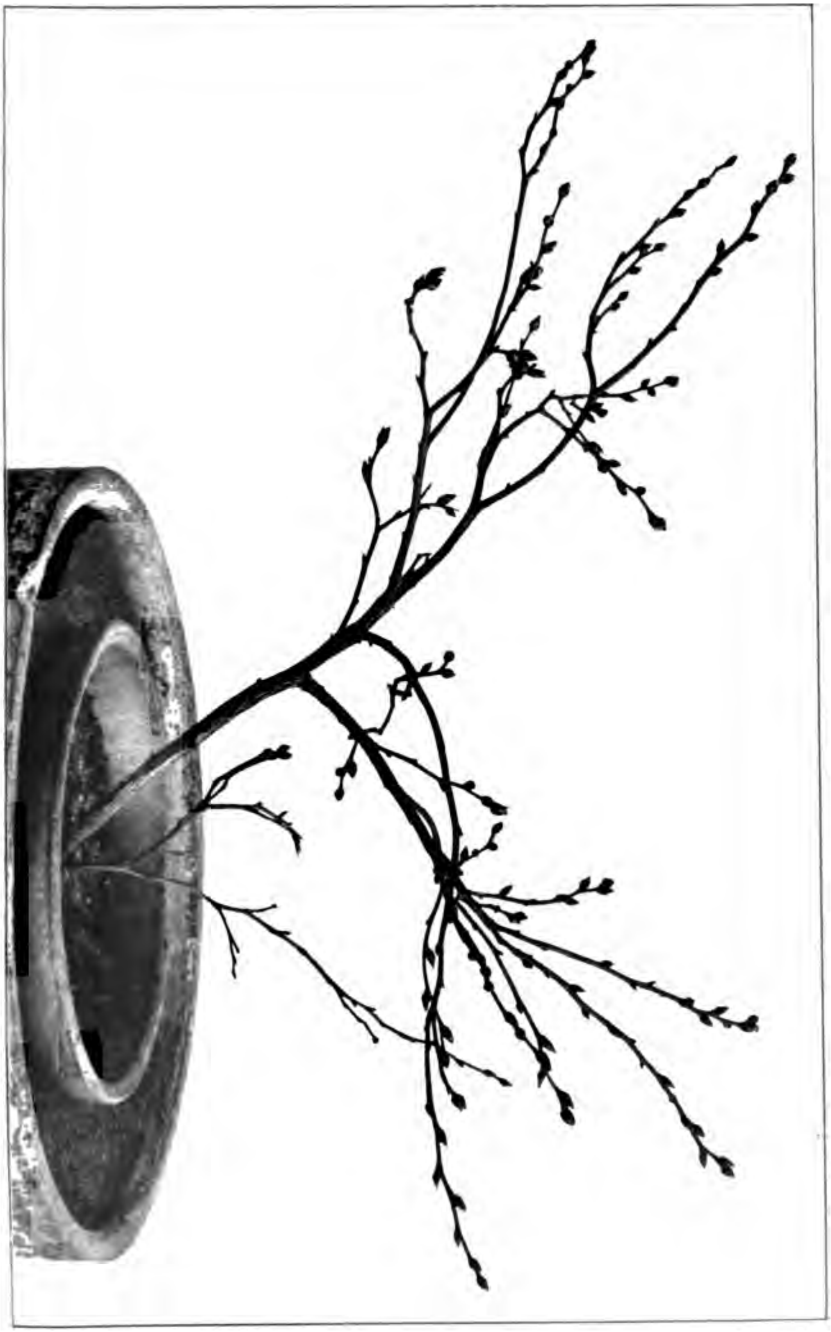
For several days after transplanting, the plants were partially shaded. Paper and the branches of various trees and bushes were tried for this purpose. Pine branches stuck in the ground on the south side of the plants were found by far the best of the shades used.

The soil about the plants was mulched in most cases with dead leaves, held in place when necessary by a little earth thrown over them.

CONCLUSION.

In conclusion, to those desiring to experiment with the field culture of the swamp blueberry, whether with wild plants, seedlings, or plants grown from cuttings, two modes of treatment are suggested, both deduced from the experiments already made. The first method, suited to upland soils, is to set the plants in trenches or separate holes in well-rotted peat at least a foot in depth, and mulch the surface well either with leaves or with clean sand. The excavations should provide ample space for new growth of the roots, not less than a foot each way from the surface of the old root ball. The peat used may be of either the bog or upland type, as described on pages 32 to 35 of this publication, and should have been rotted for several months before using. The soil in which the holes or trenches are situated should be such as to provide good drainage, the ideal condition of the peat about the roots of the plant being one of continued moisture during the growing season, but with all the free water draining away readily so that thorough aeration of the mass of peat is assured. If the surrounding soil is sufficiently porous to insure the maintenance of such a moist and aerated condition, without the necessity of mixing sand with the peat, better growth, it is believed, will be secured than when such a mixture is used.

The second method of field culture suggested is to set out the plants in a peat bog after the bog has been drained, turfed, and deeply mulched with sand. The treatment proposed is the same as that employed in cranberry culture, except that no special provision need be made for rapid flooding of the bog for winter. The ground water in the bog may probably be kept with advantage a little lower than is usual with cranberries. This method of culture is suggested not



BLUEBERRY PLANT FROM A TWIG CUTTING.

Photographed in the winter after the plant was 1 year old. The pot is plunged in sand, in a larger pot. (One-half natural size. See p. 85.)

only because of the close botanical relationship of the swamp blueberry and the cranberry and the known similarity of their physiological requirements in the matter of peat and moisture, as well as the presence of a mycorrhizal fungus in the roots of both, but also and especially because the most robust growth in all the pot experiments occurred when the roots of the plant were feeding on pure peat and the pots were surrounded by moist sand. The important effects of these conditions are discussed on pages 68 to 71. Essentially the same effects, it is believed, are secured by the system of culture used for the cranberry.

This publication closes with no special summary of results. The numbered statements which form its framework are in themselves a sufficient summary for the general reader, and one who is led by these experiments to undertake the culture of the blueberry will find it profitable not to begin his work until he has read the whole of the publication. These plants differ in their soil requirements so fundamentally from all our common cultivated crops that it is useless to expect to succeed with their culture without a thorough understanding of the principles governing their growth.

Those desiring to look into the work of earlier experimenters can find a key to the literature in F. W. Card's book entitled "Bush Fruits," or in the article by W. M. Munson on Vaccinium, in Bailey's Cyclopedia of American Horticulture.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 194.

B. T. GALLOWAY, *Chief of Bureau.*

SUMMER APPLES IN THE MIDDLE ATLANTIC STATES.

BY

H. P. GOULD,

POMOLOGIST IN CHARGE OF FRUIT DISTRICT INVESTIGATIONS.

ISSUED FEBRUARY 16, 1911.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

BUREAU OF PLANT INDUSTRY.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., July 25, 1910.

SIR: I have the honor to transmit herewith a manuscript entitled "Summer Apples in the Middle Atlantic States" and to recommend that it be published as Bulletin No. 194 of the series of this Bureau. This bulletin was prepared by Mr. H. P. Gould, Pomologist in Charge of Fruit District Investigations, and is coordinate in character with Bulletin No. 135 of the Bureau series, entitled "Orchard Fruits in the Piedmont and Blue Ridge Regions of Virginia and the South Atlantic States." It has been submitted by Mr. A. V. Stubenrauch, Expert Acting in Charge of Field Investigations in Pomology, with a view to its publication.

The information contained in this bulletin results from a systematic investigation which is now in progress by this Bureau in different fruit-growing regions of the country. The object of this work is to determine as far as possible the adaptability of fruit varieties to different conditions and the particular climatic and other requirements of different varieties.

The growing importance of early-apple culture and the increasing demand for fruit of this character have warranted the giving of special attention to this phase of fruit growing. In certain sections of the region referred to in this bulletin early-apple culture is of great importance not only because of its present degree of profitableness, but because of the fact that it has developed largely in the place of a declining peach industry.

While the varietal data and other information are based on the conditions which exist in this region and hence are not directly applicable elsewhere, it is expected that fruit growers in other regions who may be interested in the growing of summer apples will find the discussions of value to them.

The writer wishes to acknowledge his indebtedness to the many fruit growers in this region who have without reserve given him the freedom of their orchards and the benefits of their experience in the

course of the field work connected with these investigations. The assistance of his office associates in the identification of varieties and in other ways has also aided the writer very materially in the preparation of this bulletin.

Respectfully,

WM. A. TAYLOR,
Acting Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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SUMMER APPLES IN THE MIDDLE ATLANTIC STATES.

INTRODUCTION.

The extensive and systematic growing of early-ripening or "summer" varieties of apples for commercial purposes is one of the comparatively recent developments of the fruit industry. Such varieties have always had a place in the family orchard, and in seasons of abundant crops the fruit from these trees has often been sold in the local markets. Occasional commercial orchards, since the early days of the fruit industry, have contained a few trees of early varieties, the fruit of which has been shipped by express or otherwise to more or less distant markets, but in most commercial apple-growing sections early varieties have not been considered worth including in extensive fruit-growing projects. In some sections, however, during the past ten or twenty years, and especially during the last decade, the attention of fruit growers has been directed more and more to the possibilities in this direction.

A considerable demand has developed for summer apples. This demand is growing; new markets are being reached. During the past few seasons fruit growers and shippers have received an increasing number of requests from commission houses and fruit dealers for fruit of this class. Though this demand may in a measure be variously influenced from year to year by the abundance of peaches and other fruit in the market during the early-apple season, it shows an increasing appreciation of the important place which summer apples may be made to fill.

In the Middle Atlantic States, and especially in the Coastal Plain or "tidewater" region, there are several sections in which the growing of summer apples has already become an important feature of fruit growing. This phase of the fruit industry has been greatly extended here in recent years and is being still further developed. It is believed that other sections of these States, where little or no fruit is now grown, are also capable of being developed along this line. This bulletin describes the region mentioned—its conditions, advantages, and possibilities in relation to the production of early apples—and contains

a discussion of the principal varieties now grown there, with a view to indicating their relative value in the further development of the early-apple industry in this region.

DESCRIPTION OF THE COASTAL PLAIN REGION.

On account of the relative importance of the early-apple industry in the Coastal Plain region, in comparison with other sections in the Middle Atlantic States, it is a matter of convenience to adopt this region as a geographical unit of territory in this bulletin and to base comparisons and discussions on the observations made there. Its location and extent are indicated below.

GEOGRAPHICAL LOCATION.

In a general way, the division line in the Middle Atlantic States between the region commonly termed the Coastal Plain and the adjacent territory is indicated on the map shown as figure 1 by a conspicuous unbroken line. This line may be said to start in New Jersey at the mouth of the Raritan River where it empties into the bay of that name, extending in a southwesterly direction to Trenton. The Delaware River forms the division between New Jersey and Pennsylvania south of Trenton. The dividing line then continues in a southwesterly direction across northern Delaware and the eastern shore of Maryland, passing in the vicinity of Chestertown. Crossing the Chesapeake Bay, it reaches Anne Arundel County a few miles north of Annapolis and continues in the same direction to the District of Columbia. In Virginia the direction of this boundary is slightly southwest from Alexandria to the vicinity of Fredericksburg and includes a narrow strip of land along the Potomac River between these two cities. From the latter a southerly direction is followed, passing near Richmond and Emporia. A southwesterly direction is followed in crossing North Carolina, passing near Raleigh and reaching the South Carolina line at a point nearly south of Rockingham, the county seat of Richmond County, N. C. In the same arbitrary way the state line between North and South Carolina is taken as the southern limit of the region under discussion.

From a purely geographical standpoint the corresponding area of South Carolina and Georgia should be included in this unit of territory, but as practically no apples are grown in these sections they are not specifically included in the present discussion. And further, it is generally conceded that these sections are not well adapted to apple culture on account of the climatic conditions which result from their low elevation and low latitude.

It is believed, however, that the development of the early-apple industry is practicable in that part of the area of the Middle Atlantic States which lies between the Coastal Plain and the 500-foot contour

(this being largely an arbitrary boundary line). The approximate position of this contour is indicated on the map (fig. 1) by a broken line. The conditions of this section are such that the discussions

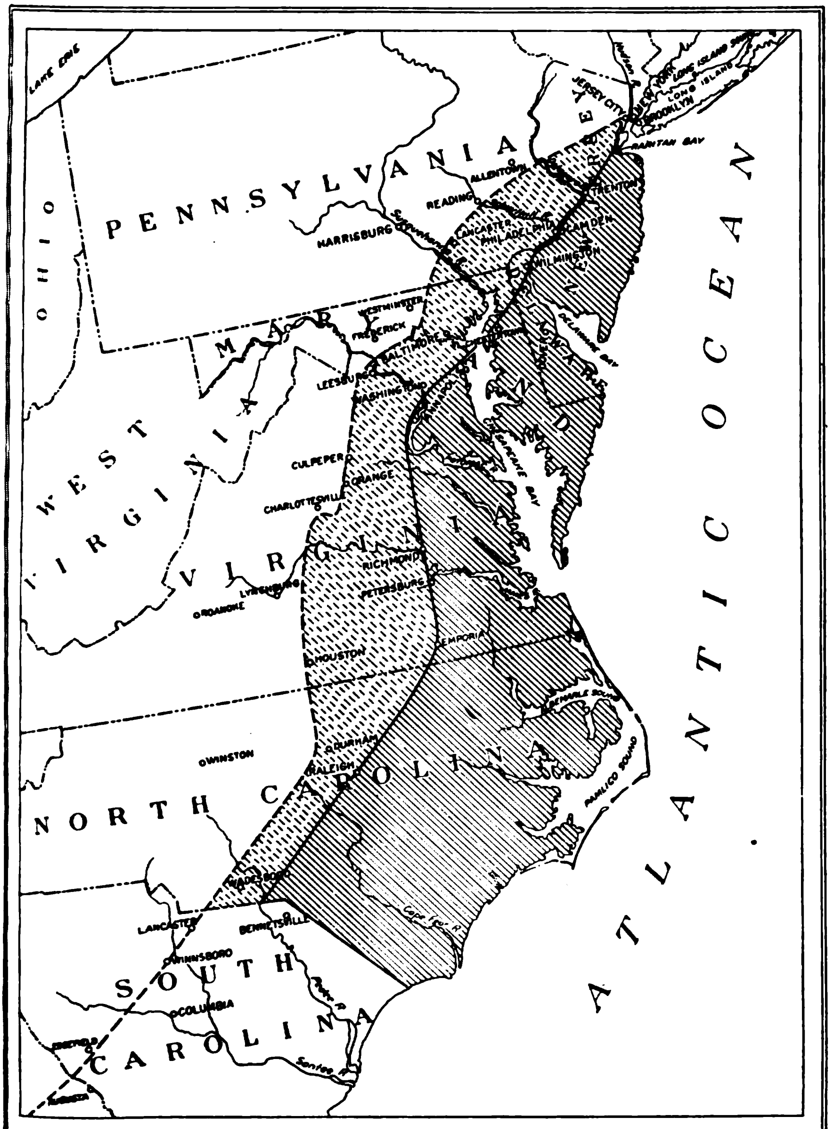

FIG. 1.—Map of the Middle and Southern Atlantic States, showing the location and extent of the regions discussed in this bulletin. The Coastal Plain is shown on the map by continuous lines, the inland boundary being to some extent arbitrary. The region between the Coastal Plain and the approximate course of the 500-foot contour is shown by broken lines.

which follow, though based on the Coastal Plain, would doubtless be applicable, with only minor modifications, to this area.

TOPOGRAPHY AND ELEVATION.

The topography of the Coastal Plain is unmarked by any special characteristics. The surface is generally level, rising slightly and gradually from the coast westward. A large number of rivers and smaller streams and their tributaries traverse the region in their course to the sea. They constitute an important factor in the soil drainage.

The elevation above sea level is comparatively slight, a large proportion of the region being less than 100 feet. Most of the remaining portions have considerably less than 200 feet elevation.

While the relative and actual elevations are practically identical and only a few feet, comparatively, above sea level, the character of the soil and subsoil and the natural water drainage provided by the streams which flow through this region insure as a rule good soil drainage. The atmospheric drainage is not so perfect as it is in regions where there is an alternation of ridges and valleys with considerable differences in relative elevations.

SOIL.

While several types of soil are represented in the Coastal Plain, the extreme characteristics of the different types which need to be considered in the present connection are not wide in so far as they have a bearing on commercial orcharding. In fact, it is evident that the influence of different methods of management in orchards located on the same type of soil could be made to exert decidedly more influence upon the behavior of varieties than would any inherent differences in the types themselves.

A large proportion of the soil is a light sand to sandy loam. The subsoil underlying much of this is of the same general character as the surface. In places, the subsoil is slightly heavier, having a small content of clay.

Small areas exist where there is sufficient clay in the surface to make a light clay loam, but it is very easily pulverized when cultivated. The subsoil of this is also heavier than that underlying the lighter types, but it is not compact. Small sections having this type of soil contain more or less gravel, from a quarter of an inch to an inch in diameter. This soil is somewhat "stronger" than the more sandy types.

Several other types might be distinguished by drawing very fine distinctions, but it is sufficient for the present purpose to consider them as variations of those already mentioned. Generally speaking, the soil is free from rocks and is easily worked.

The characteristics of the subsoil which have been described are known to extend to a great depth in many instances, as shown by wells and other excavations.

While these soils may not contain as large a supply of reserve plant food as some other types they are generally productive. Their physical properties are such as to favor deep penetration by the roots of growing plants, thus giving the plants a relatively large feeding area. The soil also responds readily to the application of commercial plant foods. It may be said in comparison with the average growth made by trees in other apple-growing sections that in the more important sections of this region they develop a good amount of wood growth and are relatively long lived.

The capillarity of the soil is strong, and the character of the subsoil makes it a deep reservoir for the storing of moisture. While this may pass off readily through surface evaporation under some conditions, it can be largely conserved by thorough cultivation. It is seldom that crops suffer more from lack of moisture here, under proper management, than in other sections having a similar amount of precipitation but more compact types of soil.

CLIMATE.

The climate of a place affects the plant life growing therein in many ways. In some one or more of its elements it is the most potent determinant of plant growth. Climate is an exceedingly complex influence, and the numerous combinations of the factors which constitute it render its effect upon plant life difficult in the extreme to interpret.

Each of these factors, as it is manifested in the climate of a place, acts in a particular way upon the varieties of apples, as of other forms of plant life, which may be grown there. The manner in which a variety responds to the influence of these factors, singly or in combination with one another, determines what the effect of the climate is upon that variety, and therefore its relative adaptability to particular purposes in that region so far as the climatic factor is concerned.

In its influence upon vegetation of all kinds, climate may be resolved into a number of elements of which the following are the most important:[a]

(1) Precipitation (rain and snow).
(2) Temperature (from day to day, and the mean).
(3) Extremes of heat and cold.
(4) Time and frequency of frost.
(5) Amount and intensity of sunshine.
(6) Humidity and transparency of the atmosphere.
(7) Direction and velocity of wind.
(8) Perhaps the electrification of the atmosphere.

It will thus be seen that climate is more than a matter of temperature and moisture, as popularly applied, though these factors are

[a] See Encyclopedia Americana, under "Climate."

doubtless the most potent of any in their effects upon plant growth. It is not intended, however, within the limits of this paper to discuss at length what these effects are, even if it were possible to do so. There is an unfortunate lack of adequate means for measuring some of these elements, which doubtless are of great importance, and of interpreting them in terms of their influence upon plant life. Records of precipitation and temperature are abundant, but they seldom represent actual orchard conditions, being taken usually at points more or less distant from fruit plantations and often with instruments attached to buildings many feet above the surface of the ground. This is true, at least, of many of the records which are continuous for any considerable period of time.

In general it may be stated that in order for a plant or a variety to succeed without irrigation there must be sufficient precipitation to maintain growth adequate to the end for which the plant is intended. As regards temperature, the extremes must be within certain more or less definite limits, and the mean, especially for the more critical periods in the life of the plant, must accord with the particular requirements of each individual. The mere matter of late spring frosts—an unfavorable extreme at a critical period—may indicate the impossibility of successfully growing certain fruits in some localities.

As applied to the region now being considered, it is sufficient to state that with certain general exceptions, noted elsewhere, the climatic conditions are favorable for the cultivation of early apples in most sections of the region. The orchards now in bearing testify to this fact. The extremes of temperature in most parts of the region are not severe, the precipitation is usually sufficient to meet the requirements, and the other climatic factors in most sections are equally favorable to the end in view.

The following tables, taken from the Monthly Weather Review for the years 1902 to 1907, inclusive, are composed of climatological records at three different stations located respectively in the southern, central, and northern sections of this region. They represent to some extent the climatic conditions which prevailed during the years mentioned and furnish one of the best available means for comparing the climate of this region with that of other sections where similar data are to be had. Such a comparison should assist in correctly forecasting for other sections the behavior of the varieties considered, so far as the climatic factors are concerned. These climatological data are also inserted for use in connection with the phenological records that appear on later pages.

As will be noted, the following table gives the monthly maximum, minimum, and mean temperatures and the precipitation. The geographical arrangement of the stations as they appear in the tables is from south to north.

TABLE I.—*Records of temperature and precipitation for Kinston, N. C., Seaford, Del., and Moorestown, N. J., for the years 1902 to 1907, inclusive.*

Place and month.	1902. Temperature. Maximum.	1902. Temperature. Minimum.	1902. Temperature. Mean.	1902. Precipitation.	1903. Temperature. Maximum.	1903. Temperature. Minimum.	1903. Temperature. Mean.	1903. Precipitation.
Kinston, N. C., elevation, 46 feet. (United States Geological Survey):	°F.	°F.	°F.	*Inches.*	°F.	°F.	°F.	*Inches.*
January	73	15	41.3	1.01	71	18	46.0	2.96
February	76	19	38.4	6.70	74	16	48.4	5.91
March	83	22	54.9	3.04	81	34	60.0	8.05
April	89	30	61.2	2.34	86	30	56.7	2.99
May	97	44	72.8	2.64	95	45	67.6	3.91
June	100	50	77.5	3.92	90	51	....	....
July	104	60	82.6	2.69	97	60	79.4	8.07
August	99	52	78.6	8.91	97	62	79.6	6.93
September	91	46	72.6	2.76	88	41	71.5	.89
October	84	31	62.9	5.13	86	27	57.4	3.28
November	81	31	57.2	4.14	71	14	....	.60
December	71	16	45.5	1.82	61	15	36.2	1.99
	....	....	....	45.10	....	....	....	[a] 45.58

Place and month.	1904. Maximum.	1904. Minimum.	1904. Mean.	1904. Precipitation.	1905. Maximum.	1905. Minimum.	1905. Mean.	1905. Precipitation.
January	67	10	35.6	4.12	76	11	40.2	0.85
February	75	17	38.2	4.10	65	15	38.1	5.06
March	79	27	51.8	5.04	88	25	56.6	2.52
April	88	28	58.6	.82	90	29	61.2	4.06
May	93	43	68.8	3.78	92	49	73.0	5.57
June	99	51	77.6	1.29	96	49	77.2	3.90
July	101	62	80.4	5.00	98	62	79.4	4.38
August	98	57	78.2	3.58	99	53	77.2	4.22
September	90	44	71.6	4.75	96	45	74.2	1.70
October	86	33	59.7	1.73	92	33	62.4	3.12
November	72	24	48.6	2.30	80	23	52.1	1.58
December	69	20	41.0	2.82	70	20	45.2	4.75
	....	....	....	39.33	....	....	....	41.71

Place and month.	1906. Maximum.	1906. Minimum.	1906. Mean.	1906. Precipitation.	1907. Maximum.	1907. Minimum.	1907. Mean.	1907. Precipitation.
January	79	21	48.0	3.68	80	17	51.4	1.13
February	74	17	44.1	4.63	72	9	42.6	2.39
March	80	22	50.4	7.53	98	25	59.2	2.39
April	94	30	63.8	.52	83	28	54.6	4.05
May	98	37	70.0	3.41	95	40	68.7	5.56
June	100	61	78.8	4.37	98	49	73.4	9.07
July	100	64	79.2	9.16	102	58	81.3	9.11
August	96	67	81.5	13.08	96	58	78.6	5.02
September	96	57	78.0	.59	97	51	77.0	3.83
October	87	28	64.4	4.13	93	29	59.0	.89
November	85	22	52.3	.84	79	25	51.2	3.19
December	77	17	46.7	1.34	79	19	46.0	3.08
	....	....	....	53.28	....	....	....	49.71

[a] This total covers eleven months only.

TABLE I.—*Records of temperature and precipitation for Kinston, N. C., Seaford, Del., and Moorestown, N. J., for the years 1902 to 1907, inclusive*—Continued.

Place and month.	1902. Temperature. Maximum.	1902. Temperature. Minimum.	1902. Temperature. Mean.	1902. Precipitation.	1903. Temperature. Maximum.	1903. Temperature. Minimum.	1903. Temperature. Mean.	1903. Precipitation.
Seaford, Del., elevation, 40 feet. (Estimated):	°F.	°F.	°F.	*Inches.*	°F.	°F.	°F.	*Inches.*
January	52	12	32.0	3.73	56	12	34.3	3.[illegible]
February	62	8	30.0	5.01	69	6	38.4	6.[illegible]
March	75	20	47.1	2.98	76	25	51.1	5.[illegible]
April	87	31	53.5	3.79	86	28	52.6	3.[illegible]
May	88	40	64.6	2.29	91	37	64.6	2.[illegible]
June	96	50	72.8	6.86	88	50	66.6	3.[illegible]
July	100	57	78.1	5.55	100	52	76.0	3.[illegible]
August	93	52	73.8	1.69	96	56	73.4	4.[illegible]
September	89	45	68.6	5.91	89	37	67.5	4.[illegible]
October	79	31	60.2	4.23	83	32	57.5	8.44
November	74	30	53.2	3.16	79	17	42.6	1.71
December	63	17	37.0	4.79	54	11	31.8	3.7[illegible]
	....	....	....	49.99	....	....	....	52.27
	1904.				1905.			
January	62	2	29.2	1.73	60	−4	29.8	4.48
February	59	3	28.5	2.32	50	−2	26.8	3.83
March	68	19	41.2	3.39	77	19	44.8	2.20
April	77	26	48.4	1.95	81	27	62.2	2.89
May	82	41	62.2	1.52	82	40	63.4	5.50
June	94	44	69.5	2.02	89	45	69.2	4.02
July	94	54	73.5	7.74	95	57	74.4	6.73
August	88	49	71.4	1.32	89	53	72.2	5.69
September	90	35	66.6	2.08	82	40	66.7	6.19
October	83	29	52.6	2.73	80	31	57.0	1.45
November	66	21	42.4	2.01	72	16	44.6	.66
December	60	2	30.4	6.07	62	17	38.3	4.58
	....	....	....	34.88	....	....	....	48.22
	1906.				1907.			
January	73	7	40.7	2.53	71	8	37.8	2.53
February	60	9	34.8	4.61	54	5	29.4	2.60
March	61	15	38.4	5.88	88	19	46.6	2.72
April	84	27	53.0	1.44	79	23	47.1	3.90
May	92	33	63.0	4.86	84	36	58.0	6.97
June	92	55	71.4	12.30	87	46	65.0	4.50
July	89	57	73.2	11.56	91	55	74.8	3.92
August	91	64	75.6	7.86	91	52	71.8	2.46
September	91	51	70.8	2.28	90	40	69.1	3.95
October	76	30	57.0	4.70	76	30	51.7	3.06
November	68	27	45.4	1.45	64	28	45.4	5.62
December	62	12	37.5	3.45	62	20	39.3	3.65
	....	....	....	62.92	....	....	....	45.88

TABLE I.—*Records of temperature and precipitation for Kinston, N. C., Seaford, Del., and Moorestown, N. J., for the years 1902 to 1907, inclusive*—Continued.

Place and month.	1902.				1903.			
	Temperature.			Precipitation.	Temperature.			Precipitation.
	Maximum.	Minimum.	Mean.		Maximum.	Minimum.	Mean.	
Moorestown, N. J., elevation, 71 feet. (Weather Bureau):	°F.	°F.	°F.	Inches.	°F.	°F.	°F.	Inches.
January	53	11	29.8	2.95	53	9	31.8	3.69
February	57	9	28.0	6.45	68	0	34.6	4.71
March	75	19	45.3	4.22	76	24	48.8	5.28
April	87	31	51.4	3.63	90	28	51.6	5.33
May	87	38	61.2	2.45	93	31	64.2	.44
June	91	48	68.3	7.30	85	45	65.0	5.65
July	92	55	73.6	7.05	94	50	73.4	5.44
August	88	49	70.6	8.44	92	49	69.2	5.49
September	87	43	65.4	5.29	88	36	65.8	4.42
October	76	27	56.7	7.59	80	31	57.0	8.79
November	76	27	50.4	2.50	73	14	41.4	1.18
December	60	12	32.9	7.34	54	9	30.0	4.48
	....	....	....	65.21	....	....	....	54.90
	1904.				1905.			
January	56	−9	24.0	3.02	54	0	27.7	2.87
February	59	0	25.6	2.40	45	−1	24.2	2.79
March	68	15	38.4	3.83	81	9	41.0	4.24
April	79	25	48.2	2.61	80	26	50.8	3.12
May	92	40	63.6	3.23	84	34	62.2	1.31
June	94	46	69.0	3.07	91	45	68.9	2.93
July	92	52	72.4	5.69	96	55	75.2	2.85
August	89	48	71.1	7.08	90	50	71.6	5.66
September	88	32	65.8	5.84	84	37	66.0	3.81
October	84	25	52.6	4.00	87	29	56.3	3.84
November	63	18	40.9	2.04	67	15	42.7	1.87
December	53	1	27.0	2.93	61	15	36.6	3.59
	....	....	....	45.74	....	....	....	38.88
	1906.				1907.			
January	72	5	37.2	2.85	67	0	32.6	2.93
February	61	4	32.2	2.06	48	0	24.1	2.86
March	58	13	35.4	5.37	86	11	42.0	2.66
April	81	26	52.4	2.71	79	23	46.0	3.68
May	90	35	62.1	2.66	85	32	55.8	5.34
June	92	48	71.5	7.33	91	41	64.8	6.85
July	90	53	73.8	4.11	90	53	73.3	4.45
August	92	62	75.2	9.43	90	51	69.8	6.48
September	89	45	69.2	3.99	88	39	67.4	6.74
October	75	29	55.1	4.20	76	26	50.8	3.89
November	68	22	44.2	1.70	62	21	43.8	5.49
December	65	8	34.2	3.34	62	17	37.2	4.25
	....	....	....	49.75	....	....	....	55.62

The following data regarding the occurrence of spring frosts at various points in this region are of particular value when considered with the blossoming dates that constitute a part of the phenological data given on later pages. These data have been furnished by the United States Weather Bureau.

TABLE II.—*Average dates of the latest spring frosts at different localities in the Middle Atlantic States.*

Location.	Average date of latest frost.	Date of latest frost recorded.	Number of years recorded.
Central and Southern New Jersey:			
Asbury Park	Apr. 19	May 29	11
Moorestown	Apr. 23	May 15	41
Vineland	Apr. 17	May 22	36
Atlantic City	Apr. 11	Apr. 25	20
Chesapeake peninsula:			
Chestertown, Md	Apr. 19	May 11	10
Easton, Md	Apr. 12	Apr. 28	11
Millsboro, Del	Apr. 17	Apr. 30	14
Princess Anne, Md	Apr. 23	May 12	10
Maryland, west of Chesapeake Bay:			
Baltimore	Apr. 4	May 3	33
Laurel	Apr. 21	May 11	10
College Park	Apr. 29	May 12	10
Solomons	Apr. 8	Apr. 27	11
District of Columbia:			
Washington	Apr. 7	May 11	37
Virginia:			
Warsaw	Apr. 14	Apr. 28	11
Hampton	Mar. 27	Apr. 6	11
Norfolk	do	Apr. 26	33

THE SUMMER-APPLE INDUSTRY OF THIS REGION.

DEVELOPMENT.

In the sections of this region where there now exist large summer-apple interests, there were formerly very extensive peach orchards. The summer-apple industry, as a commercial feature, has been developed largely since the destruction of many of the peach orchards by yellows. In fact, apple culture has to some extent taken the place of peach growing, many apple orchards now occupying land formerly devoted to peaches.

Some of the United States census figures relating to the peach interests of Delaware and New Jersey are of interest in this connection. Unfortunately these figures are not given in sufficient detail prior to the census for 1890 to admit of any comparison, but those for the year named and for 1900 stating the number of peach trees of bearing age in the States mentioned show the trend during that decade, as follows:

	1890.	1900.
Delaware	4,521,623	2,441,650
New Jersey	4,413,568	2,746,607

Similar data for Kent County, Del., are also suggestive, since very heavy plantings of peaches formerly existed in this county, and at

the present time it is the center of the most extensive summer-apple interests of any section in this region.

Census data relating to apples in this section are of little significance, as they include the trees of bearing age of all seasons of ripening, and many fall and winter sorts are grown as well as summer varieties, yet the recent extension of apple culture, especially in Kent County, Del., has been quite largely of early varieties. Data regarding the number of peach and apple trees of bearing age in this county are therefore of interest for comparison with the data as to peach trees just presented, as follows:

	1890.	1900.
Peach trees	2,335,740	824,430
Apple trees	114,371	186,457

The period of most rapid extension of the early-apple interests, however, has been during the past eight or ten years; hence, it is not shown in any available census figures.

PRESENT STATUS AND EXTENT.

A general statement as to the distribution of the orchards in this region, giving the more important centers of early-apple production, will give the reader some conception of the extent and importance of this phase of fruit culture.

In New Jersey, the principal early-apple interests are within a radius of 18 to 20 miles of Philadelphia. Large quantities of fruit are grown in this section, nearly all of which is hauled in wagons to the Philadelphia markets. A common type of wagon used for this purpose is shown in Plate II, figure 1.

There are numerous other orchards in central and southern New Jersey in which early apples are an important factor, but they are considerably isolated in their location with regard to one another, and the fruit from them is handled quite differently from that which is grown near Philadelphia.

In Delaware the important section is the central part of the State, the commercial orchards being well distributed over Kent County within a distance of 8 or 10 miles of the railroad.

In the other sections of Delaware, and in the Maryland, Virginia, and North Carolina sections of this region, early apples are grown in much the same way that they are in southern New Jersey. Family orchards and many gardens contain such varieties, and occasionally isolated orchards of commercial size are to be found, but the industry is not centralized in particular sections, though in the aggregate the amount of fruit grown is considerable.

In the sections of this region where the fruit interests have already been well developed a good system of orchard management is gener-

ally practiced. However, in many of the other sections, where frui growing at present is only a secondary matter, the orchards are genei ally greatly neglected. Little or no cultivation is given, unless i connection with the growing of interplanted crops; usually no prunin and no spraying. Under these conditions many of the orchards ar sorely attacked by insects and fungous diseases. There is no reason t suppose, however, that these difficulties may not be readily overcom by the application of the usual methods in such cases.

With relation to the last statement, however, it should be note that in the southern section of this region certain fungous diseases o the apple appear to be unusually prevalent, and should any extensiv commercial development of apple culture be considered, this featur should have full consideration. However, while the climatic condi tions may have some influence in the extent to which these disease have appeared in the past, it is not assumed that the more commoi diseases which are now noticeable could not be readily controlled by the use of certain precautions and the application of proper spray mixtures. In fact, a few orchards in this section which have been properly attended to demonstrate that this is the case, especially when varieties adapted to the region are planted.

NATURAL ADVANTAGES AND POSSIBILITIES OF THIS REGION FOR SUMMER-APPLE PRODUCTION.

The extent to which successful summer-apple culture in certain sections of New Jersey and the Chesapeake peninsula has been developed is good evidence of the natural advantages of these sections, but some of the other sections require notice in this connection.

Earliness of maturity is an important consideration, and the light sandy and sandy loam soils, which are characteristic of nearly the entire region, doubtless contribute toward this end. The temperature is usually relatively high during the period when the fruit is making its growth, without which the other factors, however favorable, would fail to produce early ripening.

The location of the region with reference to the larger markets and distributing centers of the East is likewise a favorable factor. The relationship between the points of production and distribution is always an important matter, and especially so in the handling of any quickly perishable product. In case there should be developed in the future a demand in the foreign markets for early apples, the comparatively close proximity of a large portion of this region to the eastern seaports, and the readiness with which the fruit grown therein could be landed on the docks, renders this region particularly adapted from this point of view for the supplying of such demands. Shipping facilities are likewise good. Many points in this region have access

both to rail and water transportation, a condition always considered favorable to the fruit grower.

In general, the climatic conditions are favorable for the end in view. The only exceptions that call for special notice are the late spring frosts and cold periods following unseasonably high temperatures in winter, during which the fruit buds advance to a tender stage. If these unfavorable temperatures occur during the blossoming period, serious damage is likely to result. On account of the low elevation of this region it is more subject to these conditions than regions having higher relative altitudes. In selecting orchard locations, places where late spring frosts are known to occur to a serious extent should be avoided.

GROWING THE FRUIT.

As the subject-matter of this bulletin is primarily a description of the conditions that prevail in the Coastal Plain region and an account of the different varieties of early apples grown therein and their behavior, only passing mention is made of cultural and fruit-handling methods.

In general, it may be said that the orchard management requisite for the production of this class of fruit does not differ materially from the usual methods employed in growing winter apples. The same pruning, cultivating, fertilizing, spraying, etc., are required in the one case as in the other. The later sprayings commonly recommended for late varieties are not so necessary for the earlier sorts for obvious reasons, though the early applications should be made with the same thoroughness that is required for winter sorts. It is a question worthy of consideration, however, whether later applications made after the fruit has been harvested would not be worth while, at least in the case of varieties especially susceptible to fungous diseases, in order to protect the foliage during the long period between harvesting and the end of the season. The vigor and healthfulness of the trees might thus be insured and the crop the following season perhaps improved thereby.

HANDLING THE FRUIT.

METHODS AND CONDITIONS.

The methods employed in handling early apples are much more closely allied to those used in marketing peaches than to the usual manner of caring for winter varieties. This results naturally from the character of the fruit.

As a rule the fruit is intended for immediate consumption and is not usually marketed until fully ripe, or, at least, in suitable condition to use without delay. As its period of duration is short when edible

maturity is reached, it must of necessity be used within a comparatively few days after it is put on the market. Some varieties, however, intended only for cooking, are shipped as soon as they are large enough for this purpose, without much regard to the degree of maturity which they may have reached. Although such varieties may be held longer than those marketed in a thoroughly ripened condition, they soon begin to deteriorate if held for any considerable length of time.

HARVESTING.

In harvesting early apples careful hand picking is practiced by a majority of the most successful growers. A few firm-fleshed varieties, the fruit of which ripens irregularly and drops as soon as it is well colored and fully ripe, are sometimes allowed to drop their fruit. If there is danger of the apples being bruised by striking the ground, a heavy mulch of straw is spread beneath the trees. But many of the most particular growers prefer to hand pick even these sorts, though it is rather laborious to do so on account of the ripe fruits being much scattered over the trees.

Some of the less exacting growers shake the fruit from the trees or beat it off with poles, claiming that the difference in price between the carefully handled fruit and the fruit handled by their method is not enough to justify the extra expense of hand picking. It should be noted, however, in this connection, that careless or rough handling of fruit in harvesting often accompanies indifferent methods of culture. The grade of the fruit grown frequently determines the expense that is justifiable in preparing it for market.

The period of growth from blossoming to maturity is relatively short, and the changes which occur in the development of the fruit take place with corresponding rapidity. It may be only a very short time, as measured by days, between a date when an apple is too immature to pick and the period when it becomes overripe. Because of this, several pickings of most varieties are usually made, as in picking peaches. The specimens which are small and immature when the first picking is made will commonly develop with increased rapidity, attaining a degree of perfection not reached by the more advanced specimens.

GRADING AND PACKING.

In the marketing of early apples the details of grading and packing require the same painstaking attention that the successful marketing of other quickly perishable fruits demand. Fruit that is bruised should be discarded. Though it may not appear to be defective when it is packed, bruises and other similar blemishes, especially in

case of certain varieties, become very conspicuous after the fruit has been picked a short time. Even if it looks well when packed, such fruit is likely to deteriorate greatly before it reaches the market.

Some of the early apples grown in this region are prepared for market in the orchards, but most of them are taken to packing houses, where they can be more conveniently handled. Plate III, figure 1, shows a convenient packing house. The upper portion of the building is used for storing packages, etc. There is a door on each side, thus making it convenient to receive or discharge fruit at any point on the floor. A common method of handling early apples in the packing houses in grading and packing is shown in Plate III, figure 2.

PACKAGES.

Several different styles of packages are used in this region for early apples, of which the following are the most important. In some sections the $\frac{7}{8}$-bushel crate, formerly much used in Delaware for shipping peaches, was commonly used in the earlier years and is still seen occasionally, though it has passed out of general use. The growers in the New Jersey section who market their fruit in Philadelphia use the half-bushel peach basket, usually without covers. These are shown in Plate II, figure 1. In other important sections a $\frac{7}{8}$-bushel basket with cover has been used for several years with excellent satisfaction. These baskets may be seen on the wagon shown in Plate II, figure 2. This figure also shows the manner in which these packages are loaded for hauling to the shipping station.

A few growers pack their fancy fruit in six-basket carriers and find that for some markets it pays to incur the additional expense which this style of package makes necessary. Twenty-pound Climax baskets are also used occasionally.

METHODS OF SELLING THE FRUIT.

Several methods of selling the early apples grown in this region are practiced. Perhaps the most simple one is that employed by the growers who are located in the New Jersey section within 15 to 20 miles of Philadelphia. The fruit is packed in half-bushel baskets as above mentioned, loaded on large wagons built for the purpose (Pl. II, fig. 1), and hauled directly to the commission houses or other markets. In some cases the grower runs his own stand in the market, perhaps handling truck and other farm produce at the same time. By either of these methods the packages are returned to the grower.

At the more important shipping centers the growers sell f. o. b. as much as possible, thus avoiding all risk in transit and the possi-

bility of loss from poor market conditions. This method makes it possible to ship in car lots, as the buyer fills his cars ordinarily with fruit purchased of different growers.

MARKETS AND THE PLACE HELD BY SUMMER APPLES.

Very naturally, large and relatively near-by distributing centers, such as Philadelphia and New York, receive large quantities of summer apples from this region. To a less extent, some of the New England markets, principally Providence, R. I., and Boston, Mass., receive more or less fruit, especially of certain varieties. During the past few years, however, new and more distant markets have been sought. As a result, considerable quantities of fruit from the Chesapeake peninsula section are shipped to such points as Pittsburg, Pa.; Cincinnati, Ohio; Detroit, Mich.; Chicago, Ill.; and to even other more distant western and northwestern points.

Foreign markets also offer an outlet for considerable quantities of early apples, especially when the European crop is light. The results of the experimental export shipments made by the Bureau of Plant Industry indicate that for fruit of good grade properly handled and when the markets are not overstocked with home-grown fruit, good returns may be expected from London, Liverpool, and some of the other leading foreign markets.

As an important commercial product, summer apples are a comparatively new commodity in many markets and their use has been limited. They have not filled a place comparable with that held by peaches, winter apples, and some other fruits. Hence, in the past the period of real demand for them has usually been during a scarcity of other fruits. There is evidence, however, that a very large number of consumers have now come to think of summer apples as filling a definite place in their food supply. While the demand is naturally more or less influenced by the abundance of other fruit in the markets during the summer-apple season, it is not so much dependent upon the availability of other fruit as in the earlier years and it is becoming more constant as the regularity and abundance of the supply of early apples increases.

THE PROBLEM OF VARIETIES.

CONSIDERATIONS GOVERNING SELECTION.

There are several fundamental features which should always be considered in selecting the varieties of any kind of fruit to be grown in a given region or under particular conditions. The purpose for which it is to be grown, whether dessert or cooking, home consumption or market, should be given due weight. A variety may behave in a certain manner, ripen its fruit during a particular period, and show

other habitual characteristics when growing under a certain combination of conditions of soil, climate, elevation, and cultural methods. When the variety is grown under other combinations of conditions it may behave in a very different manner. In other words, a variety is subject to the influence of the conditions under which it is grown. In those conditions there may be involved both natural factors, such as soil and climate, and factors which are more or less artificial, such as are imposed by man in his methods of culture.

It will now be understood how the subject-matter of the preceding pages has application to the notes which follow regarding the varieties that are being grown in this region. The fact is here emphasized that the statements made in the following discussion of varieties have specific application only to the fruit grown under the conditions that prevail in this region. It is hoped, however, that the information presented regarding existing conditions, and the behavior of the varieties referred to under those conditions, may be of some assistance in selecting varieties for other localities.

In the scope of this bulletin it has been the intention to include only varieties which reach maturity in some section of this region not later than the middle of September.

DISCUSSION OF IMPORTANT VARIETIES.

The following varietal list includes the most important early varieties which are grown in this region, and a considerable number of others which are known only in a limited way. No attempt, except in a few cases, has been made to give a detailed description of the varieties mentioned. Usually a few of the more prominent varietal characteristics are named in order that the reader who is unacquainted with a variety may be able to obtain readily a general idea of its appearance and quality.

Alexander.

This is a very old variety, probably of Russian origin. Its history is briefly indicated in the following:

"The evidence is reliable that Red Astrachan, with Duchess of Oldenburg [Oldenburg] and Alexander, were introduced into England by the Royal Horticultural Society from Sweden, as Russian apples about the year 1816. Wm. Kenrick in his catalogue in 1832 speaks of them as promising. In 1834 The Massachusetts Horticultural Society imported them, adding Tetofsky [Tetofski]. In 1839 the elder Manning of Salem exhibited them as home grown. Since then they have been widely distributed." [a]

The Alexander apple has become quite widely distributed in many parts of the country, though not grown in large quantities. In this region a few trees of it have been found at widely separated points. The tree is a fairly strong grower on the light soil where it has been observed. It comes into bearing quite young, but fruits mostly on alternate years. The fruit is roundish conic; usually large to very large; greenish yellow, heavily striped with red when well colored; acid; quality good; of value primarily for cooking. Its season begins the last of June in eastern North

[a] Letter of Mr. William C. Strong, Waban, Mass., April 2, 1906.

Carolina; in central New Jersey, about one month later. The variety is considered desirable as a commercial sort by some of the growers. In some sections the fruit is inclined to drop prematurely, but this characteristic has not been reported from this region in the present connection.

Bachelor Blush.

This variety is said to be of New Jersey origin, but details of its history are not obtainable. It is not widely disseminated and in this region is known only to a very small number of growers. The rather meager information obtainable concerning its behavior indicates that it may possess considerable merit.

The tree is said to be prolific, bearing more or less fruit annually. The fruit resembles the Maiden Blush apple considerably but is rather larger than that variety; frequently more highly colored and of better dessert quality. In central New Jersey ripening begins the last of August.

Benoni.

This variety originated in Massachusetts many years ago. The first published reference to it appeared in the New England Farmer in 1831. It is growing in a few orchards in central New Jersey and in at least one tide-water orchard in Virginia.

The tree grows with sufficient vigor and bears heavy crops on alternate years, though under some conditions nearly annual crops are produced. The fruit possesses high dessert quality and is of attractive appearance; color yellowish, overspread with red and striped with crimson. It is too small, however, for general commercial purposes, though for a special trade some demand might be created for it on account of its high dessert quality. This also commends it for home use.

In the Virginia orchard, above mentioned, which is located in close proximity to the coast, this variety has done especially well in recent years. The trees bear heavily and the fruit reaches a good size for the variety, obtaining a high degree of perfection. In this orchard good cultural conditions are maintained. The fruit begins ripening early in July in Virginia; in central New Jersey it is two weeks or so later.

Bibbing.

So far as information at present available indicates, this variety was first propagated and distributed in this region sometime prior to 1875, by the late Mr. Randolph Peters, whose nursery was not far from Wilmington, Del. It does not appear, however, to have been planted extensively, as only an occasional orchard in this region now contains it. On account of its very close resemblance to the Oldenburg apple, and the danger of confusion with that variety, attention is here directed to it.

In habit of growth, the tree makes a rather flat, broad top, moderately dense, and with heavy dark-green foliage. In contrast with this habit the top of Oldenburg is usually more roundish and less dense and the foliage somewhat lighter. The fruit of these two varieties is hardly distinguishable one from the other. Bibbing is perhaps less sharply acid and may be slightly earlier than Oldenburg. Otherwise it is scarcely possible to distinguish any constant points of difference between them, and even those noted as distinguishable may be so influenced by conditions as to be of little value for purposes of identification.

Bietigheimer. Synonym: *Red Bietigheimer.*

This variety is of German origin. It is growing in a small number of orchards in central New Jersey and Delaware, both on the very light sandy soils and the more loamy types.

The tree is a fairly vigorous, upright grower under these conditions, but the variety is not proving thus far to be of any special value. It is late in coming into bearing, trees 10 to 15 years old having borne very sparingly. Older trees in other regions indicate that heavy bearing is unusual. Under favorable conditions the fruit is very

large in size; skin yellowish, nearly covered with a pinkish-red blush, often with a more or less marbled effect; subacid in flavor. The fruit thus far produced in this region has been rather inferior in appearance and quality. Its season in New Jersey and Delaware begins the last of July to the first of August.

Bonum. Synonym: *Magnum Bonum.*

The Bonum apple is supposed to have originated in Davidson County, N. C., and has been in cultivation many years. It is quite widely distributed throughout the South. In this region it is growing in many places in North Carolina, largely in the older orchards, and to some extent in Virginia. It is rarely found at more northern points.

The tree is fairly vigorous and generally healthy, with dark heavy foliage. In the sections above mentioned, it is a regular bearer. The fruit is small to medium in size, occasionally large; its under color is yellow, overlaid with dark crimson; mild subacid flavor and of excellent dessert quality. In the sections referred to, its season begins early in September and continues through the greater part of October. It is even said by some growers that it can be kept all winter without special care.

For home use, a personal market, or even for general commercial purposes this variety appears to be worthy of more extensive planting in these sections. Indications point also to a range of adaptability extending as far north as central Delaware. The high dessert quality and fine appearance of the fruit make it particularly attractive. It is admirably suited for hotel or other trade where a highly colored apple of fine quality and not over large size is desired.

Bough. Synonym: *Sweet Bough, Large Yellow Bough.*

The first mentioned synonym is the name under which this variety is generally known, but it is reduced to Bough under the rules of nomenclature of the American Pomological Society. This is also the name under which it was described in 1817 by Coxe, this being the earliest published description. Its origin is obscure, except the mere fact that it is a native variety.

The Bough apple is widely distributed in many sections of the country, and in this region it is in many orchards throughout the Maryland, Delaware, and New Jersey sections, though not produced in large quantities.

The tree is only moderately vigorous under the conditions in these sections. Some complaint of its being short lived is made. A few instances of rather serious twig blight have been observed, but this does not appear to be common. Shy bearing is reported by some, but, as a rule, fairly regular and abundant crops are produced. The fruit is medium to large, greenish yellow, tender, crisp, and of a rich, sweet flavor. Its season usually lasts about two weeks in individual orchards, though occasionally the fruit is all harvested at a single picking. It may be had at some point in the sections mentioned during most of July, the exact date of maturity depending upon the location and local conditions.

Experiences differ as to the profitableness of this variety. Its principal use, on account of its flavor, is for eating out of hand or for baking. It is the one sweet early variety that is commonly grown, hence it may be of particular importance for this reason. It is probably better adapted to a special trade or a personal market than it is for general commercial purposes. It is said to sell well at some of the seashore resorts along the New Jersey and Delaware coast.

Buckingham. Synonyms: *Fall Queen, Equinetely, Byers' Red.* Nearly thirty other synonyms have been applied less generally than the ones here mentioned.

The history of this variety traces back with fairly definite records to 1777 to the garden of Col. John Byers, of revolutionary fame, who lived in Louisa County, Va. The Buckingham is quite widely distributed in many sections of the South, but is not grown in large quantities. It is in a few orchards in the Virginia and North Carolina sections of this region, but is relatively unimportant.

The tree in a large proportion of the orchards in these sections where it is found is a weak grower and more or less subject to certain diseases. The fruit, when well grown, is large; under color yellow, heavily washed over most of the surface with crimson and rather indistinctly striped; subacid, very pleasant; good to very good. In these sections its season begins early in September, but continues for several weeks so that it may be considered an early fall rather than a summer variety.

It is of doubtful value in the Virginia and North Carolina sections of this region. Even in the orchards where the trees are in good condition the fruit does not mature well and is apt to rot, indicating a lack of adaptability to these conditions. As the variety is well adapted to the conditions existing in the Piedmont and Blue Ridge regions of Virginia and North Carolina where the altitude is higher than in the Coastal Plain, it is possible that it would do relatively better in the northern portion of this region than it does in the southern.

Celestia.

This variety originated in Miami County, Ohio. The original tree is said to have been a seedling of Stillwater. It has been in cultivation for forty years or more though it has never come into general cultivation. It has been found in only two or three orchards in this region and in the adjacent areas. These are in Delaware and Virginia.

The tree is a fine, thrifty, upright grower and a prolific, nearly annual, bearer. Fruit large; roundish conical; pale yellow, moderately sprinkled with gray or brown dots; flavor rich, mild, subacid, very pleasant; quality very good. It reaches edible maturity in the Virginia location about the first of September and is slightly later farther north in the Chesapeake peninsula.

Though the trial of this variety in this region has not been sufficient to warrant definite conclusions, it is promising for its season and highly prized by the few growers who have had experience with it.

Champlain. Synonyms: *Nyack, Nyack Pippin.*

In this region this variety is known as Nyack or Nyack Pippin. It is supposed to have originated in Vermont or New York, but historical data are lacking. It is grown to a limited extent in some sections of the North, but is not generally known to fruit growers. It is in quite a large number of orchards in New Jersey and Delaware, but as in the North very many of the growers are unacquainted with it.

The tree is a fairly vigorous, somewhat upright grower, apparently long lived. It is generally productive, bearing nearly annual crops in some orchards. The fruit is medium to large; greenish yellow, sometimes with blush on exposed side when fully ripe; pleasant subacid flavor. It is usually shipped from these sections during the last week or ten days of July and early August. The fruit holds to the tree fairly well, so that it may be handled during a rather long period of time.

While of minor importance, relatively, in the sections of this region where it is grown, it is usually considered a desirable commercial variety, though perhaps less profitable than some other sorts.

Chenango. Synonyms: *Chenango Strawberry, Strawberry, Sherwood's Favorite.*

This variety probably originated in New York, though some accounts suggest Connecticut. It is grown sparingly in many sections of the North; in this region it is not being grown commercially and is to be found in but very few orchards.

The tree is fairly satisfactory in its habit of growth. Fruit is oblong, conic, above medium size; whitish yellow, striped and splashed with crimson; pleasant subacid; very good. In the New Jersey section the season begins about the first of August.

The locations where the variety has been reported are on light, sandy soil. It does not appear to be well adapted to this region. At one place in central New Jersey, under rather indifferent cultural conditions, the fruit is said to decay usually before it ripens,

and it seldom, if ever, colors well. Besides this it does not develop properly. This has been the continuous record of trees which are from 35 to 40 years old. Younger trees in southern Delaware have perhaps been slightly more satisfactory, but it is apparently of little, if any, value here.

Colton. Synonym: *Early Colton.*

This variety is said to have originated in Franklin County, Mass., on the farm of a Mr. Colton. It has been propagated more or less for nearly seventy years usually under the synonym mentioned. It has some prominence in the Delaware and Maryland sections of this region, where it is grown more or less on the light sandy soils characteristic of these sections.

The tree is moderately vigorous, healthy, and fairly prolific, but in many instances, even under good care, the fruit fails to develop satisfactorily and many culls result. It bears with a good degree of regularity, producing some fruit nearly every year. The apple is of medium size, greenish yellow, sometimes blushed on exposed side, and of subacid flavor. The normal season of ripening in these sections is about the middle of July. The fruit is sometimes handled in a rather immature condition as early as the first week in July. It matures quite evenly, so that frequently the most of the crop can be gathered at a single picking.

In the experience of some growers, this variety is not as good for shipping as some other sorts, especially when marketed in a fully ripe condition. It is inclined to turn dark under the skin if bruised, rendering it unattractive in appearance. At present it is not of great value in this region and as there are one or two other more desirable varieties, especially Early Ripe, of nearly the same season, it is doubtful if it will become of any special importance here, though possessing some merit

Cornell. Synonyms: *Cornell's Fancy, Cornell's Favorite.*

The original tree of this variety is said to have stood on a farm owned by Mr. Gilman Cornell and situated in Southampton township, Bucks County, Pa. It is not much grown in this region, being confined mostly to a few orchards in the New Jersey section. Light sandy soils characterize the locations where it has been observed. Some complaint is made that the trees lack vigor and are short lived.

The fruit is medium size or above, much resembling Chenango, with which it is doubtless sometimes confused. It is of better dessert quality than that variety. It appears to be better adapted to the section above mentioned where it is being grown than Chenango, since it develops to a good degree of perfection without manifesting the defects referred to under that variety. It begins to ripen about the middle of August in central New Jersey.

Cross.

The Cross apple originated near Fair Play, Washington County, Md., but has not become widely known. So far as observed in this region, it is growing in only one orchard, which is located in Caroline County, Md.

The tree is a strong, vigorous grower and an abundant bearer. The fruit is large; roundish oblate; greenish yellow, striped and splashed with light red; slightly subacid; good to very good in dessert quality; also recommended for culinary purposes. In the section above mentioned it ripens from the middle to the last of August. It has not been sufficiently tested in this region to demonstrate its value, but is considered very promising for its season by the one grower interviewed who has it under observation.

There is a Russian variety grown under this name which is a late-keeping sort.

Dawes. Synonym: *Dawes Porter.*

Origin, Massachusetts. This variety is known only to one or two growers in this region, hence it has not been tested sufficiently to determine its value. It is a large apple; light yellow, shading to a darker color with a suggestion of red; mild subacid,

rich; very good. It ripens during August in the central part of the Chesapeake peninsula.

Early Edward. Synonym: *Edward Early.*

Aside from the fact that this variety is of American origin, its history is obscure. It was mentioned by James Mease in the first American edition of "The Domestic Encyclopedia," which was published in Philadelphia in 1804. It is grown to a very limited extent, and in this region it is to be found in only a small number of the older orchards.

The tree is fairly vigorous and productive. Where the San Jose scale is a serious pest it appears to be peculiarly resistant to this insect. It has been observed that when certain other varieties are even destroyed by it, this one remains nearly free from attack. The fruit is of medium size or above; yellow, washed and striped with red and crimson; subacid, pleasant; very good in dessert quality. In the central and northern sections of this region, ripening occurs the last of July and the first of August. When fully ripe, rotting at the core is frequently serious. For this reason its value for market purposes is doubtful, but it may have a place for home use on account of its high dessert quality.

Early Harvest. Synonym: *Prince's Harvest.*

This apple was first mentioned in American pomological writings in 1806. It is therefore a very old variety and supposed to be of American origin. Few varieties have become so widely disseminated over a large portion of the country as this one. Throughout this region it is probably the most widely grown of any sort. However, it is to be found more generally in the older orchards, having been planted but little in recent years.

Generally the tree is fairly vigorous and healthy, though in some sections of this region, especially in the North Carolina portion, it is often badly affected with stem or trunk tumors or knots [a] and certain other fungous diseases. The fruit is, typically, medium to large in size; pale-yellow color; pleasant subacid flavor; dessert quality, very good. Ripening begins at southern points in this region by the middle of June; in the northern portion it is about three weeks later.

As ordinarily grown, the fruit is very irregular in size and grade, many poor, knotty specimens being produced. It is much subject to injury from the plum curculio. Hence a considerable proportion of the crop is usually of low grade, which renders it less profitable commercially than some other varieties of the same season. As a market sort, therefore, it is not popular. Its high dessert quality, however, gives it a place in the home orchard. It is probable that it is better adapted to the climatic conditions in the northern or New Jersey portion of this region than at southern points. Here the tree is generally less subject to disease and as a rule the fruit develops to a higher degree of perfection.

Early Joe.

This variety originated many years ago at East Bloomfield, Ontario County, N. Y., in the same orchard with Northern Spy and Melon. It is said to have received its name from the fact that a man by the name of Joe was for a time accustomed to steal the fruit early in the morning before he was in danger of being observed. It is not much cultivated in any section. In this region, it exists in only an occasional orchard. The trees which have been observed here are making a rather poor, unsatisfactory growth. The fruit is small to medium; oblate, conic; dull greenish-white undercolor, with dull red washing and striping; tender, juicy, mild subacid, and of high dessert quality. Its season in the central portion of this region is the last of July and early August. Its high quality commends it for home use, but it

[a] See Circular 3, Bureau of Plant Industry, U. S. Dept. of Agriculture.

is too small for market purposes. On account of the weakness of the tree, however, it is of doubtful value in this region for any purpose.

Early Ripe.

This variety is supposed to have come originally from Adams County, Pa., but the point is open to question. It is evidently not generally known over a wide range of country, but in this region it is one of the most important of the early commercial sorts of the white or yellow skinned varieties. It is grown extensively, however, only in the Chesapeake peninsula sections. There appears to be no well-defined reason why it has not become known and generally planted in New Jersey, but it

FIG. 2.—An Early Ripe apple tree in Delaware, about 15 years old.

is practically unknown in that section; the same is true in the Virginia section. In North Carolina it is to be found in a small number of orchards.

The tree is rather upright in habit of growth, with strong tough limbs not easily broken. (Fig. 2.) It bears early and in most cases abundantly, with nearly annual crops. The fruit is medium or above in size, yellow, subacid, of firm texture, good quality, and less subject to insect injury, especially the plum curculio, than many other varieties.

In season it is one of the earliest. In some places it is the first variety to be shipped from the section where it is extensively grown. It cooks well before it is fully ripe,

and this fact is often taken advantage of by the growers, who market it earlier, by a few days, than could otherwise be the case. The first pickings are often made in central Delaware during the last days of June; it is usually all marketed by the middle of July. In the North Carolina section it is about two weeks earlier. The fruit holds to the trees well, however, so that its market period, including the period of full maturity, is longer than that of most early sorts, extending over nearly a month, if desirable to hold the fruit that length of time. On the other hand, the fruit matures quite uniformly and it may generally all be gathered in two pickings if desired. Its texture remains firm when fully ripe; hence, it is possible to handle the fruit largely in accord-

FIG. 3.—An Early Strawberry apple tree in Delaware, about 50 years old.

ance with market conditions. It appears probable that it would be a satisfacto variety for its season throughout the region. It has been planted extensively in rece years in the Chesapeake peninsula section instead of Early Harvest. In one or tw instances, this variety has not given its accustomed satisfaction, being late in comi into bearing and otherwise faulty. Such experiences, however, are exceptional.

Early Strawberry.

This variety is supposed to have originated in New York. It was referred to pomological literature prior to 1840, and is widely disseminated though not exte

sively grown. It is quite widely distributed in the New Jersey and Chesapeake peninsula sections, but is seldom seen in other portions of this region.

The tree is a strong upright grower and apparently long lived. (See fig. 3.) It is slow in coming into bearing. As a rule, only very light crops are borne before the trees are 10 or 12 years old, or even considerably older in some cases. The fruit is small to medium; roundish conic; yellowish undercolor, frequently almost entirely overspread with red, sometimes striped with darker red; texture rather firm; very good to best in dessert quality. The season of ripening begins about the middle of July in central Delaware and lasts for two or three weeks, the fruit ripening very gradually. Several pickings are therefore necessary.

Opinions differ widely in regard to the value of this sort. It is considered one of the most profitable by some; others regard it as practically worthless commercially. The late-bearing habits of the tree have already been mentioned. This is a serious objection to many growers. Unless thoroughly sprayed, the fruit usually scabs very badly. It is too small for ordinary commercial purposes, but on account of its attractive appearance and high dessert quality it is well suited to a personal market or some special trade. It is said to bring fancy prices at some of the summer resorts along the coast of New Jersey and Delaware. It is thus evident that satisfactory results can be realized only when the fruit is grown under high culture and is skillfully marketed.

English Codlin.

As the name suggests, this variety is of English origin. It is cultivated very little in this country. In this region it is confined almost exclusively to the New Jersey section.

The tree is a good grower. Fruit roundish oblate; large; yellowish green, with bronzing on exposed side; subacid; quality good, especially desirable for cooking.

The place which this sort fills in the early-apple growing industry of the New Jersey section is rather distinct from that held by most other early varieties. As indicated elsewhere most of the early apples are marketed in baskets or other small packages, but this variety is generally shipped in barrels. It meets with special favor in the Boston markets, where very satisfactory prices are usually realized. It does not reach maturity in this section until the last of August or first of September, but it develops to a good size for culinary purposes, for which it is especially valued a month previous to this time, and as soon as it is large enough to cook harvesting and shipping are generally begun. While in some sections it may be held until fully matured, the above method is said to be one of the most satisfactory ways of handling it in New Jersey.

The variety is particularly well adapted to the heavier soils in this section, and when the trees are well cared for, nearly annual crops are produced. A single grower in the Virginia section of this region has reported this variety. In this case it is highly prized.

Fanny.

The Fanny apple originated in Lancaster County, Pa. It is referred to in the revision of Downing's "Fruits and Fruit Trees of America" for 1869 as "a new apple of great promise as a market sort." It is not, however, very much grown in any section. It is in a few orchards in the New Jersey and Chesapeake peninsula sections, but is relatively unimportant at present.

The tree is a fine grower in the nursery, of upright habit, and good vigor. In the orchard it is only moderately productive. In fact, some growers offer this as one objection to it. The fruit is medium or above in size; clear yellow undercolor, overspread with bright red, showing some stripes of a darker shade; pleasant subacid flavor; good to very good.

Its season in central Delaware is the last of July and early August, though it frequently extends over a considerable period. As a commercial variety for this region it is of doubtful value. In at least one orchard which is in a good state of cultivation, the fruit nearly all drops soon after it sets. Some growers speak of it as quite irregular

in the degree of perfection which it attains from year to year. On the other hand, other growers state that it gives satisfactory results under their conditions, though in some of these instances it is not considered of much value commercially. It is evidently more easily influenced by conditions than many varieties.

Garrettson. Synonyms: *Garrettson's Early, Somerset Harvest.*

This variety originated at Somerset, N. J. It has never been much disseminated and hence is but little known in any section.

The tree is a spreading grower, and is reported to be prolific. Fruit medium to large; bright greenish yellow; mild subacid; not of high dessert quality, but good for cooking. It ripens during the last of July and early August in the central part of the Chesapeake peninsula. The variety has not been sufficiently tested to determine its value in this region. It is doubtful if it is in any way superior to other better known sorts of the same season.

Glowing Coal.

This variety was disseminated some years ago by a New Jersey nursery, but it has not become generally known in this region. By some it is considered identical with Ohio Nonpareil, but available evidence does not support this opinion. It has been observed in but a single orchard, which is located in west-central New Jersey. The trees in this case are but 10 or 12 years old, hence it is not possible at the present time to draw any very definite conclusions about the merits of the variety. They have made a strong healthy growth. Light crops have been produced thus far, though the trees have blossomed full several times.

The fruit is large; roundish; greenish yellow, washed and splashed with crimson and with a slight overspread of gray; pleasant subacid; good to very good. Its season in west-central New Jersey is the last of August to the first of September. The tree characteristics and the quality of the fruit would make this variety a desirable one for its season, but it can not be generally recommended on account of its fruit-bearing proclivities.

Golden Sweet.

This variety is of Connecticut origin. It is not much grown in any section, but widely disseminated. In this region it is in a few orchards at widely separated points.

The tree is a strong grower and a good bearer. The fruit is large; roundish; yellow; rich, sweet; good to very good. It is considered by those who have it in this region a desirable variety for a sweet summer apple. As there is but small demand for sweet apples, however, it is doubtful if this would be a profitable market sort here. Its season is the last of July to the first of August in the middle sections of this region.

Grand Sultan.

This variety is of Russian origin; it is but little grown in this country. In this region it is in but a very few orchards. The one in which it has been under close observation for several years is located in the central part of the Chesapeake peninsula. The chief point of interest concerning it is its similarity both in tree and fruit to the Yellow Transparent apple. Its resemblance to Thaler is also close enough to be a source of considerable confusion. The best distinguishing difference between the Grand Sultan and these other two varieties, as grown in the section mentioned, is its relatively short, thick stem, which is a fairly constant characteristic.

There are perhaps more marked differences between this variety and the Yellow Transparent in some other regions. It is claimed in one section, at least, that the Grand Sultan tree is more vigorous and more upright in habit of growth than the Yellow Transparent and that it is more subject to twig-blight and less productive. These differences, however, as already noted, do not appear under the conditions existing where these varieties have been critically observed for a number of years. The Grand Sultan apple bears early and abundantly. Its season is the same as that of the Yellow Transparent.

Gravenstein.

This is a German introduction, but when it was first brought to this country is a matter of doubt. It appears quite certain that two trees were imported and planted in a garden in Boston in the spring of 1826. There is some evidence that scions were imported at another time; this may or may not have been at an earlier date. The variety is widely distributed throughout the country. In this region it is one of the most common and important varieties of its season, except in the North Carolina section, where it is rarely found.

The tree is a strong, vigorous, spreading grower, producing a large bearing surface. It comes into bearing fairly young, but not so early as some others. Under high culture it produces nearly annual crops, but as ordinarily grown the "off-year" crop is usually small. It is, however, a heavy bearer in full crop years. The fruit is medium to large; roundish oblate, angular; yellow, striped and splashed with bright red; subacid, aromatic; very good.

It is primarily an August apple in New Jersey and the Chesapeake peninsula, though the "drops" are frequently shipped the last of July. Most of the fruit is usually shipped from points as far south as central Delaware by the middle or 20th of August, while it is frequently held in some of the New Jersey orchards until some days into September.

The characteristics of the fruit make it an excellent general-purpose variety. It is excellent for cooking, for dessert, and likewise a good shipping variety. Its long season of ripening commends it for the home orchard where only a few trees can be grown. It is said to be a satisfactory variety to put in cold storage. While there has been very limited experience in handling it in this way, as is true of all early varieties, the possibility of holding it when desirable to do so may be worthy of consideration by growers in this region.

Hawthornden.

This is a Scotch variety which was brought to this country many years ago and which has been disseminated to a slight extent in some sections. So far as observed it is confined in this region to a very small number of orchards in the New Jersey and Chesapeake peninsula sections. It is unknown to most growers.

The tree is said to be a slow grower in these sections and is improved by top-working on some other vigorous sort. It bears annually and abundantly. The fruit resembles that of Maiden Blush somewhat; there appears to have been some confusion between these two varieties. Fruit medium to large; roundish oblate; pale yellow, with blush on exposed side. It ripens early in August, the same season as Maiden Blush, and is considered superior to that variety by the small number of growers who have expressed an estimate of its value. The general reputation of the variety, however, places it as inferior to Maiden Blush in flavor.

Horse.

Much confusion exists in regard to the application of the name Horse, as several sorts of doubtful identity are known more or less locally by it. In some sections the name has nearly the significance of a type name, any large, yellow apple ripening early in the season being called a Horse apple. The variety to which the name is properly applied has been in cultivation many years. Its place of origin is obscure, but it is commonly credited to North Carolina. It is found in many of the older orchards throughout the South. At one time it was considerably planted in Indiana, but it is rarely found in the North. In this region it is common in the North Carolina section, occasionally in Virginia, but rarely elsewhere.

As observed in the North Carolina section, the tree is considerably subject to twig-blight; trunk or stem tumors are also common. However, the trees are given very little attention here, so that in comparison with the standard varieties in other sections of this region this fact should be considered.

For the purpose of aiding to establish the correct identity of this variety a detaile description of it follows: Form roundish; size large; cavity regular, medium siz deep, abrupt with some russet markings extending over base; stem short, mediu stout; basin regular, medium size, slope gradual, furrowed and russeted; eye ve large, open; surface moderately smooth except ribbing; color yellow, with delica blush on some specimens, sometimes small patches of russet; dots variable, mostl small; flesh yellow, medium-fine texture, juicy; core round, conic, clasping, mediu size, partially open; flavor subacid, rather rich; quality good to very good. I ripening season extends over a considerable period, beginning in the North Caroli section by the middle of July and continuing through August.

Under good conditions this would doubtless be a satisfactory sort for southern lat tudes of low elevation, both for home use and local markets.

Jefferis.

This is a native variety of Pennsylvania, having originated with Mr. Isaac Jefferi Newlin Township, Chester County. It was awarded a premium offered by the Pennsy vania Horticultural Society for the best seedling exhibited in 1848. It is qui widely distributed through the North, but is to be found mostly in the older orchard It is almost unknown in this region, having been observed in only two or three orchar which are widely separated from one another.

The fruit is medium in size, oblate; greenish yellow with broken stripes of crimso sprightly subacid; quality, very good. It has a comparatively long season, whic in the Virginia section of this region begins about July 20. Its high dessert qualit commends it for home use and a fancy retail trade, but it is too small for gener commercial purposes. It would apparently do well in the central and norther sections of this region under good cultural conditions.

Jersey Sweet.

The origin of this variety is doubtful, but New Jersey is commonly supposed t be the section whence it came. It is quite widely distributed in the Nort though it is not extensively grown. It exists in a few orchards in the central sectio of this region, but is unknown to most of the growers.

The fruit is medium to large, roundish; yellow undercolor washed with mixe light red, splashed and striped with bright crimson; sweet, rich; of very good desse quality. In the Virginia section it usually begins to ripen from the 10th to the middl of August. It may be worthy of consideration as a sweet variety for this region an is referred to here primarily to call attention to its possible value.

July. Synonym: *Fourth of July.*

This variety, which is of the Tetofski type, is said to have reached this countr from Cassel, Germany, and to have been introduced by Mr. C. F. Jaeger, Columbu Ohio. On the other hand, another account states that it was introduced into Eng land from Russia during the lifetime of Mr. Thomas Andrew Knight, and thenc found its way into Virginia. From this section it was disseminated northward an westward under the name Fourth of July, its original name having been lost. Thoug apparently more or less distributed in various sections of the country, it remain unknown to most fruit growers. In this region it is confined primarily to the Ches peake peninsula section.

The tree makes a vigorous upright growth, with large, glossy, rather coarse foliage (See fig. 4.) It begins to bear young, trees 3 and 4 years old frequently producin some fruit, but it does not reach full bearing as young as some varieties do, neithe has it proved as uniformly productive. Some orchards which have been plante 10 to 12 years have not yet borne much fruit, though light crops have been produce for several years. The general conditions, however, in the particular orchards i question are not materially different, so far as can be determined, from those of othe orchards in which more satisfactory results have been obtained. The fruit is abov

medium in size; conic; dull yellowish, lightly washed and striped with red; subacid; good.

In the commercial orchards of the Chesapeake peninsula this variety ranks as one of the important market sorts, yet it is not held in universal favor, even in different orchards which are under practically uniform conditions. Perhaps its strongest claim to an important place is its early season of ripening. In many orchards in this section it is often nearly all marketed by July 10, though in such cases it is usually

FIG. 4.—A July apple tree in Delaware, 12 years old.

picked in a rather immature condition. From the middle to the 25th of July, as a rule, may be considered its normal season. It appears to be rather more susceptible to the influence of relatively slight cultural differences than many varieties are.

If the fruit is bruised it quickly turns dark; it also discolors badly if slightly overripe, and sometimes cracks. While fairly heavy crops are frequently produced, there is usually a larger percentage of culls than in many varieties. The fruit is borne largely in clusters, especially if the trees are heavily loaded. It will thus be seen that this variety possesses rather serious faults, yet it is considered a fairly profitable variety by many on account of its sequence in ripening and the time at which it can be marketed.

Kane. Synonyms: *Cain, Cane, Red Cain.*

This variety originated in Kent County, Del. It has been disseminated but very little; even in the section where it originated very few growers have any knowledge of it.

The tree makes a good growth and apparently bears fairly well. The fruit is medium to above in size; oblate conical, regular; whitish yellow with waxy appearance, heavily shaded with crimson; crisp, juicy; good. In the Chesapeake peninsula section its season is about the middle of September or before, but the fruit will keep several weeks. While not strictly a summer sort, it apparently has some merit for its season, though not sufficiently tested to determine its full value.

Keswick. Synonyms: *Codlin, Keswick Codlin.*

This is an English variety which has been grown more or less in this country for many years, but not extensively in any section. It is in a few orchards in the New Jersey section of this region.

The tree is moderately vigorous. The fruit is medium to large; roundish oblong, conic; greenish yellow; acid; good. Its season of ripening is about the same as that of the English Codlin, but as in case of that variety it is frequently shipped before it is fully mature. On some of the heavier soils of this region, which are to be found in the section from which this report comes, the fruit is said to have a soft texture, does not mature well, and is of little commercial value. It is reported to have been substituted frequently by nurserymen in filling orders for the English Codlin, to which it is claimed to be very much inferior in the section above named.

Kirkbridge. Synonym: *Kirkbridge White.*

The place of origin of this variety is unknown. Many years ago it was planted considerably in the Middle West, especially in Indiana, being brought there from New Jersey by Quakers when going to that State for their yearly meeting. At the present time it is almost unknown in this region, being reported from only one or two points.

The tree is a slow upright grower and an early abundant bearer. The fruit is roundish; medium size; color, greenish white, sometimes with slight bronzing on exposed side; tender, juicy, subacid; good. In Delaware it ripens about the middle of July.

Lowell. Synonyms: *Greasy Pippin, Tallow Apple.*

This variety is of unknown origin, aside from the fact that it is a native sort. It is quite widely distributed in numerous sections of the country, especially in the older orchards. It is rarely found in this region, but occurs occasionally in orchards in the northern sections.

The tree is a vigorous, spreading grower, and produces nearly annual crops. The fruit is above medium size, yellow, brisk acid flavor, and good to very good in quality. In the New Jersey section it begins to ripen about August 1. It is rather perishable, decaying soon after mature, or in some cases even before; its period of ripening extends over a space of 2 or 3 weeks. The premature decay of the fruit renders it less desirable than some other sorts of the same season.

Maiden Blush.

The Maiden Blush apple originated in New Jersey many years ago. It was first described in 1817 by Coxe, who then stated that it was esteemed in the Philadelphia markets. It is grown and still being planted over a wide range of territory and is remarkable in the fact that it is successful in so large a number of the apple-growing districts of the country. In this region it has been widely planted, though relatively of much greater commercial importance in the New Jersey section than elsewhere. It is, however, a standard sort for its season in the Chesapeake peninsula section. At southern points in the region it is found much less frequently, but is a variety known to many who have orchards.

The tree is a strong grower, as a rule, seldom showing defects of any kind. (Pl. IV, fig. 1.) With good culture, nearly annual crops are produced. The fruit is above medium size; pale yellow with blush, sometimes becoming a brilliant red on exposed side.

In some locations in Delaware shipments usually begin the last of July, but in New Jersey, where it has become of most importance, its shipping period is usually from the middle to the last of August. It is a valuable market sort, though it does not ripen at the season of highest prices. It is considered one of the standard sorts for the sections in this region where it is most grown.

A few growers who have this variety report adversely concerning it, but such experiences are rare. No explanation for such results is apparent. It may require higher cultural conditions than some varieties.

A few growers have put the fruit in cold storage for a period of two to four weeks with gratifying results. It is said to hold well in storage for the time named, and this permits placing it on the market in some seasons, at least, when prices are better than they frequently are during August.

Metz.

This variety is said to have originated in Jones County, N. C. It has apparently been distributed to a small extent locally, but is not widely known, even to those who have orchards in the tide-water section of this State.

The tree makes a fine, healthy growth, noticeably free from fungous diseases. The fruit is good size, oblate, smooth, more or less striped with red. It ripens in North Carolina the last of July and early in August. It is said to be excellent for cooking, and especially good for cider, producing a much larger quantity of juice than most varieties. It is recommended by some for growing near the coast.

No mature specimens of this variety have been seen by the writer. Its merits, aside from the tree characteristics noted above, are given here as reported by parties who are growing it.

Muster.

Aside from the fact that this variety was introduced many years ago, having been described by Warder in "American Pomology," published in 1867, nothing appears to be known relative to the history of this sort. It is likewise almost unknown to fruit growers. As far as observed, it is confined to a single orchard in this region, which is located in Caroline County, Md.

The tree makes a good growth with noticeably healthy foliage. The fruit is medium or above in size; oblate; yellow, covered with mixed red and crimson; fine grained, juicy; subacid, aromatic, rich; best quality. Its season is from the middle to the last of August in the section above mentioned. It is considered a valuable variety by the one grower who is acquainted with its merits, with whom it is proving nearly an annual bearer. Its high dessert quality commends it for home use, though for commercial purposes its season of ripening may be such that it would not be regularly profitable.

Oldenburg. Synonyms: *Duchess of Oldenburg, Dutchess, Borovitsky.*

This variety is of Russian origin. It is commonly supposed to have been first introduced into this country in 1834 by the Massachusetts Horticultural Society[a] at the same time that Alexander, Red Astrachan, and Tetofski were imported from the Royal Horticultural Society, London, England. However, unless the synonym Borovitsky was applied at a very early date to some other variety, it was introduced prior to 1833.[b]

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[a] See the quotation under Alexander for further historical information.

[b] Genesee Farmer, vol. 3, no. 24, 1833, p. 188.

The Oldenburg apple has become widely disseminated in many States, especially in the upper Mississippi Valley, where it is of value on account of the hardiness of the tree. It is not extensively grown in the Middle Atlantic States, though it is well represented in the sections where commercial orcharding has been developed. Occasional trees of it are also found in the more southern sections of this region.

The tree is a good grower, fairly vigorous, with dark, healthy foliage, though evidently not making a large tree. Some twig-blight has been observed, but it is not common. The tree forms a roundish, though spreading head. It bears nearly annually, usually producing abundant crops. The fruit is medium in size or above; yellow undercolor, well streaked with red when ripe; subacid; good. Its market period varies somewhat from year to year and with different growers. About the middle to the last of July, however, appears to be an average date for marketing in the New Jersey and Chesapeake peninsula section, but the fruit can be cooked satisfactorily before it is mature. It ripens quite evenly; the entire crop can frequently be gathered in two pickings. It keeps well after it is picked, having a tendency to shrivel instead of decaying, especially if picked before fully ripe. Its use is for culinary purposes rather than for dessert.

This is proving one of the most satisfactory varieties among the earlier sorts for growing near the coast at southern points. It would apparently be a profitable sort to grow more extensively in this region than is being done at present.

In this connection attention should be directed to the fact that there are several Russian varieties of the Oldenburg type which are very similar to that variety both in appearance and in season of ripening. Due care should be taken not to confuse any of these sorts with Oldenburg.

Orange Pippin (New Jersey).

This is a very old variety of unknown origin. The earliest records trace it to Genesee, N. Y., though it is not assumed that this was the place where it originated. It is commonly supposed to have come in the first place from New Jersey, where it is now cultivated to a limited extent in some of the older orchards. It evidently is rarely found elsewhere in any of the other fruit-growing sections of the country.

The tree is thrifty and long lived. The fruit is medium to large; yellow; subacid; and good to very good. It reaches maturity from the first to the middle of August, though as with so many of the early sorts it is frequently shipped at an earlier period, before it is fully ripe. It is said to hold well in cold storage for a short period, but it has not often been handled in this way.

There is a French variety by this name, but it is a later apple.

Parry White. Synonym: *White Wax.*

The origin of this variety is uncertain, but it probably came either from Pennsylvania or New Jersey.

So far as observed, it is grown commercially only in the New Jersey section of this region, and even here it is not an important sort. While the trees tend to bear annual crops under the best care and very heavy crops on alternate years under ordinary culture, the fruit is too small to be profitable, especially as it possesses no characteristics which make it particularly desirable in any way. It is a small, rather sprightly subacid apple with a white skin, beginning to ripen the latter part of July in New Jersey, but extending over a relatively long season.

Porter.

Porter is a New England apple which originated on the grounds of Rev. Samuel Porter, Sherborn, Mass., about 1798. It is found in many sections of the North in the older orchards. In this region it is quite common in the New Jersey section, but practically unknown to growers in other sections. The tree is long lived and not possessed of any serious faults.

The fruit is medium to large; oblong conic; yellow, in some cases having considerable blush on the side exposed to the sun; very good to best quality. Its season is about August 1 to 15.

It bears fairly well in New Jersey, though not as regularly as many other sorts. The fruit does not "take" well on the market, even though of good size and attractive appearance. It is therefore not a profitable apple to grow. It is a variety primarily for home use, either for dessert or culinary purposes.

Primate.

Until quite recently the origin of this variety was obscure, but investigations made within the past few years have apparently been successful in tracing it to its original source. In this connection the following quotation is of interest:

"The first tablet in New York State in memory of any apple was erected in the town of Camillus, Onondaga County, on the original site of the Primate apple tree. John T. Roberts, Syracuse, N. Y., on the 11th of September, 1903, caused a bronze tablet to be erected there. On this tablet is the following inscription:

On this farm Calvin D. Bingham, about 1840, produced the marvelous
PRIMATE APPLE.
Named by Charles P. Cowles,
God's earth is full of love to man.

"The ceremony called together a goodly number of people. It was a beautiful thing thus to commemorate an apple that is famous throughout New York State."[a]

This variety is quite common through the North and East, though not grown extensively. So far as observed, it is confined to the New Jersey section of this region. It is, however, in only a small number of orchards. Here the tree is not a strong grower, being considered somewhat tender and rather short lived. It is only moderately productive.

The fruit is medium in size or above; greenish white with slight blush on exposed side; subacid; and good to very good in dessert quality. Its season is about the middle of July, but it frequently extends considerably later as the fruit does not mature uniformly. The fruit is tender fleshed, hence not considered a good sort for shipping to distant markets, though good prices are reported when it is well handled. Its high dessert quality recommends it, however, for home use.

Randolph. Synonym: *Unknown.*

Though the exact origin of this variety is not known, a single tree, or at most, two trees of it, standing on a farm in Newcastle County, Del., were the first to receive recognition. This occurred in 1869. What was the source of this tree or trees, if there were more than one, has never been determined.[b]

The variety has been distributed in a limited way in the middle latitudes in the East and Middle West, but is not grown extensively. In this region, so far as observed, it is confined to orchards in Kent County, Del. But here it is not considered an important variety at the present time.

The tree is a vigorous grower, but in most orchards where it has been observed it is inclined to be less prolific than is desirable, and the foliage is often injured by some of the leaf-blight fungi. The fruit is small to medium in size; white, washed with crimson and striped with darker crimson; firm texture; mild subacid flavor, but not of high quality. Its season begins about the middle of July, continuing for about two weeks.

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[a] Proceedings of the Fifty-third Annual Meeting of the Western New York Horticultural Society, 1908, p. 151.

[b] For further historical information and detailed description of this fruit, see Yearbook for 1902, U. S. Dept. of Agriculture, p. 472.

While the Randolph apple possesses some good qualities, particularly firmness of texture and attractiveness of appearance, and ripens at a fairly good time, yet, on account of its small size and light, irregular bearing proclivities, it is not considered of special value by most of the growers in this section. The fact that it ripens practically with Williams, which is a finer and larger apple, has also had an influence in the matter, the latter being considered superior in essential particulars. In certain sections of the country, where it is being grown in a limited way, greater value is attached to it than by the growers in Delaware.

Red Astrachan.

Though this variety is of Russian origin, doubtless from the province of Astrachan, it evidently first reached this country through England, being introduced by the Massachusetts Horticultural Society in 1834.[a] It was also introduced direct from Russia in the large collection of varieties imported in 1871 by this Department.

This variety is generally distributed throughout the North, and is also one of the most important early varieties in this region. It is grown more at southern points in the region than most other early varieties. It is reported as doing fairly well in close proximity to the salt water at points along the Virginia coast, as well as at other places farther south.

The fruit is medium to large; under color greenish yellow, almost entirely covered with deep crimson, in some cases showing more or less striping; flavor a sprightly acid, too sour to be pleasant for dessert purposes, but excellent for cooking. In season it is essentially a July apple in the central and northern sections of this region. The characteristics of the tree are shown in Plate IV, figure 2. It is a strong grower, with heavy dark foliage. It is late in coming into bearing, seldom producing much fruit before it is 8 to 10 years old. Heavy crops are generally borne every other year, with light ones on the "off" year.

In the New Jersey section but few are marketed before the 10th to the 15th of July. In the North Carolina section its season begins by the middle of June. As the fruit matures unevenly, the ripening period extends over a space of two or three weeks. It should be picked as soon as the fruit is fully ripe, or slightly before, else it soon becomes mealy and often cracks.

The fruit is borne largely in clusters, the individual specimens of which ripen irregularly, one at a time. It is difficult to gather the ripe apples without at the same time removing large quantities of fruit which have not reached a desirable stage of maturity. When the fruit is shipped as soon as it reaches a desirable size, as is frequently done, without special regard to color, the proportion of poorly colored specimens in a picking is of little or no consequence; but when highly colored fruit is desired, this characteristic is objectionable in the variety.

The fruit is somewhat inclined to decay in some orchards before it is ready for market, but this is not a general experience in this region under good cultural methods. There are apt to be a good many small and otherwise unmarketable apples, so that in close grading there is a heavy percentage of low-grade fruit and culls.

While this variety has some rather serious faults in this region, it also has many points of merit, and there appears to be no other red sort to substitute for it, especially in point of season.

Red June. Synonyms: *Carolina Red June, Carolina Red, North Carolina Red June.*

The place of origin of this variety is in doubt, but it is generally assumed to be North Carolina. It has long been in cultivation and has become very widely disseminated, especially in middle latitudes and the South. In this region it is quite common in the Chesapeake peninsula and Virginia sections, and in the North Carolina section it is perhaps grown in more orchards than any other early sort.

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[a] See the quotation under Alexander for further historical information.

The tree is of fairly vigorous, upright growth and generally productive. The fruit is small to medium in size; oval, somewhat irregular, inclined to be conic; when fully colored nearly the entire surface is deep red, with a light bloom; tender, juicy, with brisk subacid flavor; quality good to very good. Its season of maturity usually begins from June 10 to 15 in the North Carolina section; in Delaware it averages about three weeks later, continuing for about two weeks.

Under good cultural conditions it bears more or less annually, with a good proportion of fairly heavy crops. It probably does not withstand neglect as well as some varieties do, but it responds readily to good culture. The foliage is somewhat subject to some of the leaf-spot fungi. Apple scab is frequently serious on the fruit if not well sprayed, but with proper attention to these details excellent fruit of the variety is grown. There are some indications that rather finer fruit is produced on the heavier soil in this region than on the very light sandy types.

The small size of the fruit is the most serious defect as a commercial variety. Some seasons, however, it is profitable as a market sort and is always desirable as a dessert apple for home use.

In some sections of this region, especially in North Carolina where this sort has been widely grown for many years, there is a considerable number of varieties, mostly unnamed and of local distribution, that very closely resemble Red June in appearance and in other ways. They may be seedlings of this variety, though as a rule little or nothing is known of their origin. The most of them ripen about with Red June and are similar to it in size, color, and flavor. Others are larger in size, some are distinctly more acid, while still others are sweet in flavor.

Roadstown. Synonym: *Roadstown Pippin.*

This is a local variety which originated in southern New Jersey near a place by the name of Roadstown, and, so far as observed, its cultivation has not extended much beyond the region of its origin.

The tree is a strong upright grower. It produces very heavy crops and tends to bear annually. The fruit is large; greenish yellow, frequently bronzed on the exposed side; subacid; rather oblate in shape; good dessert quality, and especially fine for cooking. It does not reach full maturity until about September 1, but it is a large apple and develops to a good size for culinary purposes relatively early in the season, so that shipping begins by the latter part of July. In this respect it is similar to English Codlin, and like this variety it usually meets with a ready sale in the Boston markets at more satisfactory prices than most other varieties with which it comes into competition. In this section of New Jersey, where the soil is heavier than in most places in this region, the fruit apparently possesses much merit as a commercial sort. It is suggested for careful testing in other sections.

Sandbrook.

This variety originated near Sergeantsville, N. J. It was introduced about twenty years ago, but it has not been much disseminated. It is growing in a very small number of orchards in the Chesapeake peninsula and New Jersey sections of this region.

The tree is a strong grower in the nursery, but of moderate growth as it becomes older. It is prolific when full bearing age is reached. The fruit is small to medium; prettily washed with red and striped with bright crimson; subacid; good to very good. It ripens from the last of July to the middle of August in the central part of the Chesapeake peninsula. The small size of the fruit renders it undesirable for market, but it is considered valuable for home use by some growers.

Smokehouse. Synonyms: *Gibson's Vandevere, Mill Creek Vandevere, Red Vandevere.*

This is a very old variety which apparently originated during the latter part of the eighteenth century on the farm of Mr. William Gibson near Lampeter, Lancaster County, Pa. It was called Smokehouse because the tree stood near the building used for smoking meats. It is widely known in the middle latitudes south of and including

Pennsylvania and east of the Mississippi River, though not grown in large quantities. Occasionally it is grown farther west, but not commonly. In this region it is more of a fall apple than a summer variety, although at southern points it should be grouped with the early sorts. It is more often found in the New Jersey section than elsewhere, but it holds relatively an unimportant place.

The tree makes a large, spreading top; it probably does not come into bearing quite as early as many varieties do, though not considered particularly late in reaching bearing age. The fruit is medium to large; greenish yellow, washed and mottled with red or crimson, sometimes more or less overspread with gray; prominent russet dots; subacid; good to very good. In the New Jersey section, as above indicated, it is a fall apple, ripening about the middle of September, and it may be kept for several weeks or even months, but at southern points it reaches maturity the first of September.

For a large portion of this region this appears to be a good general-purpose variety for its season. The trees bear well; it is a good market variety of sufficiently high dessert quality to have a place in home orchards.

Sops-of-Wine.

This is an old European sort which has become more or less disseminated in this country, but it has never been extensively grown. It is seldom included in recently planted orchards. It is rarely grown commercially in this region, but an occasional tree of it is found in a few orchards in the central and northern sections.

The tree makes a good growth and bears at an early age. The fruit is roundish, medium size, yellow, shaded and splashed with deep red, frequently becoming so completely shaded that the striping is obscured. Flesh is rather dry, subacid, and possesses a peculiar characteristic flavor which is exceedingly pleasant to some, but less agreeable to others. The fruit ripens about the middle of July. It often decays rather badly about the calyx before it is ripe, and drops considerably. Under neglected conditions the fruit is very irregular in size; also scabs badly if not sprayed. So far as observed, and in the opinion of those who know the variety in this region, there is little to recommend it for planting here.

Starr.

The best available records indicate that this variety originated near Woodbury, Gloucester County, N. J., on the grounds of Judge John Moore White, which were later owned by a Mrs. Starr. A son of Mrs. Starr is said to have been in the legislature about 1865 with the late William Parry. He gave Mr. Parry some scions of this variety, who propagated it under this name. The Starr has remained comparatively unknown in most sections, and in this region it is confined almost entirely to the New Jersey section, where it is grown to a considerable extent.

The tree makes a strong upright growth; bears early and abundantly, giving nearly annual crops under good cultural conditions. (See fig. 5.) The apple is large; roundish oblate; greenish white; subacid; good. It matures somewhat irregularly, but it is essentially a July apple in season, usually beginning to ripen by the 10th to the 15th of the month though not fully ripe until about the first of August. A good size is reached comparatively early, and as it cooks well before it is ripe, it is generally marketed accordingly. In fact, it should not be allowed to become too ripe before picking as it soon becomes mealy. Picking may thus be governed in a measure by market conditions, and if desirable its season may be made to extend over a considerable period. It is essentially a cooking apple, for which it is much sought after by those who know its qualities for this purpose.

In a few instances the trees have twig-blighted badly, but this is not a usual experience. The fruit shows bruises rather badly, which necessitates careful handling.

This variety possesses qualities which would appear to recommend it for more general planting in a large portion of this region. It is growing in importance.

Summer Hagloe. Synonym: *Hagloe.*

This is a very old variety supposed to be of American origin, though at one time apparently confused with an English cider crab apple called "Hagloe" and attributed to an English or European origin. Details of its early history, however, are obscure. It is not known to fruit growers generally, but in this region it is of considerable importance in the New Jersey and Delaware sections, though rarely grown in any of the other sections. The tree is a slow grower; the terminals are rather thick and blunt, thus making a tree of quite distinctive appearance. (See fig. 6.) Under good conditions of culture, very heavy crops may be expected in these sections on alternate years, and usually considerable fruit in "off years." It usually bears at 5 or 6 years of age.

FIG. 5.—A Starr apple tree in New Jersey, 8 years old.

The fruit is medium to large; oblate; whitish yellow, lightly striped and splashed with red on the exposed side, rarely becoming more highly colored; flesh rather tender, juicy, subacid; quality good; valuable for cooking rather than for dessert purposes. In the sections above mentioned ripening begins from the 15th to the 25th of July and continues about two weeks. The fruit is not generally marketed until it is nearly mature.

In most of the commercial orchards in these sections where this variety is grown it is considered an important and a profitable sort to grow, selling well in the markets. An occasional exception to this experience occurs, however, even in orchards that have received unusual attention, the variety being unproductive and unsatisfactory in nearly every essential particular. No explanation of such failures is apparent.

The tree is noticeably susceptible to serious injury from the San Jose scale, even when most other varieties are damaged but slightly.

Summer King.

The place of origin of this variety is in doubt, but it is generally supposed to be North Carolina. It is not grown in any section extensively and is comparatively unknown. This applies also to this region, as it has been located in only two or three orchards.

The tree is upright in growth, vigorous, and fairly productive. The fruit is medium to large; yellowish green, striped with crimson and red; mild subacid; very good in dessert quality. The season of ripening is comparatively long, extending through August in the Chesapeake peninsula section or even longer in some cases. In the

FIG. 6.—A Summer Haglöe apple tree in New Jersey, 48 years old.

North Carolina section the fruit is ripe about the middle of July. It is highly rec ommended by some for this region, especially in the central and northern section for dessert and also for market. The fruit reaches a good size early, so that it coul be shipped over a long season, as is Starr, Wealthy, and some others. It is not widel enough tested, however, to warrant making heavy plantings of it.

Summer Rose. Synonyms: *Lippincott, Woolman's Harvest.*

This variety originated in New Jersey. It is an old variety, being referred to i the earliest American literature (Domestic Encyclopedia, 1804) relating to pomolog Though quite widely grown in this region it is not produced in large quantities.

The tree is a good grower, somewhat spreading, productive, bearing nearly annu crops. The fruit is small; roundish oblate; whitish, striped and blotched with re

tender, juicy, sprightly subacid; quality is excellent as a dessert fruit. Not only the flesh, but the skin also, is so tender that bruising results from any other than the most careful handling. The small size of the fruit also further renders it of little value for commercial purposes, but its high dessert quality recommends it for home use. It is in the height of its season about the middle of July or a little later at central points in this region.

Tetofski. Synonym: *Tetofsky.*

This is another one of the Russian introductions which was brought to this country through England. Further historical details appear in a quotation under Alexander. The dissemination of this variety has been quite extensive, though it is not grown in large quantities in any section. It is in a few quite widely separated orchards in the Chesapeake peninsula and New Jersey sections of this region but it is of quite secondary importance.

The tree is a very upright fairly strong grower and a prolific bearer. The fruit is medium in size; roundish, oblate conic; juicy, sprightly acid; of good quality. It is more desirable for market and for cooking than as a dessert apple. Its season in the central part of the Chesapeake peninsula begins usually from July 10 to 15, with a rather short period of duration.

Several growers variously located in the Chesapeake peninsula and New Jersey consider this a fairly good variety for its season, though perhaps not of sufficient value to take the place of other better-known varieties of the same season of ripening. The tree is especially hardy and is probably rather better adapted to sections farther north than it is to this region.

Thaler. Synonym: *Charlottenthaler, Government List No. 342.*

This is one of a large number of varieties introduced from Russia in 1870 by the United States Department of Agriculture. It has never become widely known, at least not under its correct name or either of its synonyms. So far as observed it is confined in this region to a single orchard which is located in Caroline County, Md. In the present connection the chief point of interest is the similarity of the fruit to Yellow Transparent, which is one of the most important commercial varieties in this region. It is also very similar to Grand Sultan, previously mentioned. Comparing this variety with the Yellow Transparent, the fruit of the two sorts is practically identical so far as any constant distinguishable characters of individual specimens are concerned. Thaler is claimed by some to be a very few days later in ripening the bulk of its crop, though this is open to question. The owner of the one orchard in Caroline County, Md., in which these two varieties, also Grand Sultan, are growing, after a considerable number of years of close observation, is convinced that as they grow in his orchard, these two—Thaler and Yellow Transparent—are indistinguishable from each other in season, productiveness, or fruit characteristics, but that there is a marked difference between the trees, Thaler being a more vigorous grower, which is readily noticeable even in the nursery, and being much less subject to twig-blight than Yellow Transparent.

In some sections of the country the Thaler tree is reported to be less vigorous and productive than the Yellow Transparent. The limited range of observation in this region does not warrant definite conclusions regarding the relative merits of these two varieties for this region, but a thorough test of Thaler in the different sections appears desirable.

Townsend.

This is a very old variety, the origin of which traces to Bucks County, Pa., where it was discovered by Mr. Stephen Townsend nearly a century and a half ago in an old Indian clearing. While grown more or less in various sections in the older orchards, it is unknown to most fruit growers. It has been observed in but a single orchard in this region, located in west-central New Jersey.

The tree is a vigorous, spreading grower, fairly productive, but the crops are mostly alternate. The fruit is medium size or above; oblate conic; pale yellow, striped with red; subacid; good to very good in quality. The fruit usually is well colored by the last of July or the first of August in this section and drops as soon as colored. The ripening period lasts for a month or six weeks. By those who know the variety the fruit is esteemed for home use on account of its high dessert quality, but it ripens too irregularly to make it a desirable market sort.

Trenton Early.

The early history of this apple is obscure; it is known, however, to have been in cultivation for a long time. It was listed by Heikes & Wharton, a Pennsylvania nursery firm, in their catalogue for 1823. It is quite widely disseminated, but, as is the case with so many varieties, it is in comparatively few orchards. It would seem probable that it is in some of the older orchards in the New Jersey section of this region, though in the course of these investigations no trees of it have been found in this section. One or two orchards in the Chesapeake peninsula section contain it, but it is not common.

The fruit is large; conical; greenish yellow, sometimes with bronzed blush; pleasant subacid; good to very good. Its season in the sections named would probably begin the last of July or early in August.

Wealthy.

The exact date of origin of this variety is uncertain, but it was about the year 1861. The fruit was first described in 1869. The original tree is stated to have been grown from a collection of crab-apple seed which Mr. Peter M. Gideon, of Excelsior, Minn., obtained from Bangor, Me. There is very little about the variety, however, either in tree or fruit to suggest that it is of crab parentage. On the other hand, it is said that some of its seedlings show crab characteristics. This would appear to give some support to the claim regarding its parentage.

It is one of the most important late fall and early winter varieties in the upper Mississippi Valley, where cold endurance of the tree is of paramount importance. In recent years it has become quite widely disseminated. It has been planted considerably in the New Jersey section, though rarely elsewhere in this region. It is becoming an important variety here to supplement the earliest ripening sorts.

The tree grows well, with rather long slender branches when young. The foliage is sometimes rather small and weak, though apparently not especially subject to fungous diseases. The fruit is medium to large; roundish oblate; yellowish white under color, heavily striped and splashed with red when well colored; flesh tender, juicy, subacid; quality very good; desirable either for cooking or dessert. In the New Jersey section it is fully ripe from the latter part of August to the first of September, but the variety usually bears heavily and the fruit develops to a sufficiently large size for culinary purposes relatively early. Hence marketing of the green fruit begins frequently the last of July or the first of August, the picking being so done as to thin the fruit on the overloaded trees. By such methods the green fruit is made a source of some revenue, and that which is allowed to remain until later is improved as a result of the thinning. In this way the fruit may be handled throughout the month of August. The variety is generally regarded by those who have it in the New Jersey section as a very desirable and profitable sort to grow.

Williams. Synonyms: *Williams Early*, *Williams Red*, *Williams Early Red*, *Williams Favorite*.

This variety has been in cultivation since about the middle or latter part of the eighteenth century. It originated at Roxbury, Mass., and was first exhibited in 1830 at a meeting of the Massachusetts Horticultural Society. It is grown considerably in the North and East and to a lesser extent in some other sections.[a]

[a] For further historical information and a detailed description of this variety, see the Yearbook of the United States Department of Agriculture for 1908, p. 476.

Its distribution is general throughout the sections of this region in which the commercial growing of early apples has become important, particularly in Delaware and New Jersey. In the North Carolina section it is occasionally found, but is not of special importance at present.

The tree is rather a poor grower in the nursery as well as in the orchard, making a spreading, often rather irregular, top. (See fig. 7.) Probably top working on some vigorous upright grower such as the Northern Spy would be an advantage. Early and abundant crops are generally produced. The crops are more or less alternate under indifferent cultural conditions, but with good attention considerable fruit may be expected nearly every year. The fruit is above medium in size; roundish oblong, conic; when well colored, heavily striped with dark red or crimson, becoming nearly a solid color; subacid; quality good. The season in the New Jersey and Chesapeake

FIG. 7.—A Williams apple tree in Delaware, about 10 years old.

peninsula sections usually begins about July 20, varying from this date a few days in different years, according to climatic and other conditions. The market period generally lasts about two weeks.

Some varieties, as noted elsewhere, are handled as soon as they are large enough to cook, but this one though it develops to a fairly good size is not marketed, as a general practice, until it is well colored. In fact, its fine color is one of its most attractive features. Ripening is quite irregular, so that picking is rather difficult, especially from large trees. As the fruit drops soon after attaining full color, some growers allow it to remain on the trees until it matures and drops instead of picking it by hand. (See Harvesting, p. 20.)

On account of its season of ripening, the fruit sometimes reaches the markets when they are well stocked with peaches, cantaloupes, and other fresh fruits. The prices of apples are more or less influenced thereby. Yet because of the many desirable

market qualities which this variety possesses it is very satisfactory as a rule and more profitable than most of the second early sorts. It is one of the comparatively few varieties that are grown in large quantities. An occasional adverse report is heard relative to its behavior in these sections, but they are so exceptional that they do not materially affect the general standing of the variety.

There is apparently confusion in some sections of this region in connection with this variety. In the above-mentioned sections where it is commercially important it is perhaps better known by its synonyms Williams Early or Williams Early Red than by its approved name. In other sections it is commonly called by another synonym, Williams Favorite. Occasional statements are made in this region, however, that Williams Early Red and Williams Favorite are distinct varieties, the former being a scraggly, poor grower, but a good bearer; the latter, a strong, vigorous upright tree, but a shy bearer and not commonly grown.

Since the apple known to the growers of this region as Williams Early or Williams Early Red is undoubtedly Williams, as above described, considerable effort has been made to determine the identity of the variety known in this region as Williams Favorite. Though the latter variety is commonly spoken of, few growers are actually familiar with it, and it has been difficult to locate bearing trees. It appears probable, however, that the Williams Favorite of some, at least, is the Sops-of-Wine, as it has recently been determined that the latter variety has been disseminated somewhat under the name Williams Favorite, which name has been erroneously used as a synonym of that variety. Some young trees planted for Williams Favorite (of this region) and which correspond in tree characters to this variety, as above described, have been identified as Sops-of-Wine. While this still leaves the matter open to some doubt, it at least is a partial clearing up of the confusion. There may be still other varieties not yet examined in this connection which are being grown under the name Williams Favorite.

Yellow Transparent. Synonym: *Government List No. 334.*

As the synonym of this variety implies, this is one of the importations from Russia made by the United States Department of Agriculture in 1870. It has been widely disseminated, being now grown in many parts of the country. It possesses an unusually wide range of adaptability, as is evident from the high degree of success with which it is grown in many sections.

In this region it is one of the most important early varieties. It is more extensively grown in Delaware than in any other section, but it is being planted throughout the region.

Under high culture the tree makes a fairly strong upright growth for the first few years (Pl. I), but in many orchards the growth is rather short and stubby. This gives the tree a somewhat stunted appearance. Closer planting is possible than with most varieties on account of the small size of the tree. Frequently a few apples are borne the first year after the trees are planted, and often when 2 and 3 years old considerable fruit will set. Full bearing is reached at an early age. Nearly annual and fairly abundant crops may be expected in this region under good cultural conditions.

The tree sometimes twig-blights rather badly, though in some orchards it seldom appears. It is considered short lived, but because of its early-bearing proclivities and abundant crops, longevity is not so important a matter as with some other varieties. The fruit is above medium size; roundish conic; beautiful, clear yellowish white, the skin having a waxy appearance; subacid; good to very good.

In the Chesapeake peninsula section shipments frequently are made the latter part of June, often as early as the 20th to the 25th of the month. But at this time the fruit is rather immature and small. By the first week in July it is usually in prime condition for shipping from this section, and by the 10th to the 15th of July it is generally all marketed. Some growers, however, ship the fruit in a more immature condition than

others, and this makes the shipping dates of one orchard differ accordingly from those of another in the same locality. In the New Jersey section the tendency is to let the fruit reach a somewhat more mature condition than is customary in the Chesapeake peninsula section, hence shipping dates are relatively later in the former section. In the Virginia and North Carolina sections the season begins from the 10th to the 20th of June. Ripening is quite uniform, so that the entire crop can usually be harvested in two pickings. If conditions are favorable for growth after the first picking is made, the fruit which is allowed to remain on the trees will develop rapidly in size so that the second picking usually comprises the best grade of fruit produced. Formerly the Yellow Transparent was considered too tender for a market variety, but experience has demonstrated that with reasonable care in handling, especially if the fruit is picked while it is still firm, fairly long-distance shipments can be safely made if the packing is well done. In some of the experimental export shipments made by the Bureau of Plant Industry this variety carried in good condition, in cold storage, to the English markets.

As mentioned under Thaler, the fruit of Yellow Transparent very closely resembles that variety, Thaler possibly being a few days later, and the tree rather more vigorous than Yellow Transparent.

PROMISING VARIETIES FOR TRIAL.

There are a number of varieties of summer apples of considerable prominence in other sections that, so far as observed, are not being grown in this region but which would doubtless be of value both commercially and for home use. Some of the more promising of these are the following:

Coffman.

This variety has been known for many years in some sections of Tennessee, particularly in Lauderdale County. It was named for the owner of the farm on which one of the first trees of it to attract attention stood. It was propagated and introduced to the trade in 1888. It is not widely known among fruit growers.[a]

It is a vigorous, upright grower and produces regular annual crops. The fruit is of the Red June type and it may be a seedling of that variety; medium or above in size; roundish; under color yellow, washed with mixed red and stripes of purplish red, turning to almost a black-red when highly colored; subacid; good to very good. It is said to ripen about with Red June.

On account of the value of the Red June apple and others of its type in some sections of this region, and the similarity of Coffman to that variety, it is considered worthy of extended trial here.

Early Cooper. Synonym: *Cooper's Early White.*

There is much uncertainty in regard to the place of origin of this variety. By some it is thought to have come from Iowa, but the evidence is not conclusive. It is grown to a considerable extent in some parts of the Middle West. In some sections of Kansas and Oklahoma it is very successful.

The tree is an exceptionally fine stocky grower, bears early, and is productive. The fruit is medium size; round or roundish oblate; clear greenish yellow; quality good. It is considered especially desirable for cooking, while its firm texture makes it a satisfactory sort for shipping. Probably it could be marketed from the central sections of this region by the last of July.

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[a] For further historical information and a detailed description of this variety, see the Yearbook of the United States Department of Agriculture for 1909, p. 377.

Summer Extra.

This variety probably originated as a chance seedling near Quincy, Ky. It is not known generally to fruit growers.

The tree is a strong, handsome grower, bears early, and is prolific in sections where it is in cultivation. The fruit is medium to large in size; roundish; yellow with blush on exposed side; pleasant subacid; dessert quality good to very good. For cooking it is said to be especially fine. It would probably ripen at central points in this region during the last of July or early August.

Summer Rambo.

The origin of this variety is uncertain, though it is commonly supposed to have come from southeastern Pennsylvania, but no definite information appears to be obtainable.

Several other varieties, notably Summer Rambour, or Rambour d'Ete, an old French variety that was formerly grown more or less in this country, Grosh, and Western Beauty have been confused with this one. But it is pretty definitely determined that these are all distinct varieties, though possessing some rather strong points of similarity.

Though not found growing in this region in the present connection, the Summer Rambo is often sold in local markets from orchards in the Maryland and Virginia sections of the adjacent region.

The tree is a strong vigorous grower and an early and abundant bearer. The fruit is described in considerable detail as follows: Form oblate; size large; cavity wide, large, deep, slope gradual; basin regular, medium, slope gradual; surface moderately smooth, some erupted russet dots; color yellow, lightly washed with pale mixed red, a few bright-crimson splashes and broken stripes; dots numerous, russet, many erupted; skin thick, tenacious; flesh yellowish, texture fine grained, breaking, juicy; core oblate, clasping, medium to small in size; flavor subacid, rich; quality good to very good. In the vicinity of Washington, D. C., the fruit is ripe soon after the middle of August. It is apparently worthy of attention in the Coastal Plain region both for commercial purposes and for home use.

Wilson June.

The Wilson June variety, as nearly as its history can be traced, came from a nursery in Washington County, Ark., that was abandoned during a portion of the civil war period. The trees were subsequently dug and planted in local orchards. The original tree was probably one that was obtained from this source.

The fruit is distinctly of the Red June type, though considerably larger than that variety and sweet in flavor. The tree is thrifty and apparently a good bearer. For many years it has been grown locally to a very limited extent, but during the past few years it has been attracting some attention and has been propagated more extensively than formerly.

Though the range of its adaptability has not been determined, it is likely that wherever the Red June can be grown successfully this variety may prove to be of value when a sweet apple is desired.

OTHER VARIETIES.

In the course of these investigations a considerable number of other varieties than those mentioned have come under observation or have been reported by growers in the interviews had with them by the writer. For various reasons it is not practicable to discuss each of these separately. In some cases the varieties are practically unknown in the region and apparently are not well adapted to the

conditions or possess such characteristics as to render them of no apparent value to the fruit interests of this region. In still other cases the varieties are local and relatively unimportant. For these and other similar reasons it has seemed best to confine the discussion largely to varieties which are of value and to certain other varieties that apparently possess little or no merit but which sooner or later are likely to come to the attention of fruit growers in this region for consideration. A few other sorts not now in cultivation in this region so far as known but which are considered promising are also discussed.

In this connection there are one or two varieties, or possibly more, grown largely in a local way in the North Carolina section of this region which should be mentioned here. These are variously known as "Early May," "White May," "June Apple," etc., and ripen the last part of May or early in June.

It is possible that some of these very early sorts may prove to be White Juneating, an old English variety that was more or less grown in the South in the early years under various names.

SUMMARY OF VARIETIES.

As a means of indicating the relative importance of the different varieties referred to in the foregoing pages in the different sections of this region and the approximate time when the season of use begins, the following table has been prepared. In the column which follows the varietal names the use to which each sort is adapted is indicated by the initial letters *d*, *k*, and *m*, either singly or in combination, as is required. Varieties of special value for eating in a fresh state are designated by *d* for "dessert;" *k* signifies "kitchen" or culinary use; *m*, that the variety is suited for market purposes.

In the columns headed "Relative importance" the comparative extent to which the several varieties are grown in the different sections is shown. The varieties rated 1 are those which are grown the most extensively in the sections so designated; varieties marked 2 are grown to some extent in the sections so marked, but not so extensively as those rated as 1; varieties which are found only occasionally, hence relatively unimportant at present, are rated as 3.

Promising varieties which are at present grown but little and the value of which is not yet fully determined are grouped together and follow Table III. It should be further stated that where a variety is rated the same in a section in which early-apple culture is an important industry and one in which it is still undeveloped commercially it does not mean that that variety is of equal importance in the two sections on the basis of the quantity of fruit produced, but rather that in comparison with other varieties grown in the respective sections the relative proportions are approximately the same.

The dates given in the columns headed "Season begins about" refer to the approximate periods when the different sorts are fit for use or can be marketed, and not necessarily to the date of full maturity. Where the 15th of a month is stated, it should be broadly interpreted to mean the middle of the month; likewise the 25th refers to the last of a month rather than to an exact date. A similar interpretation should be given to other dates mentioned.

TABLE III.—*Use, relative importance, and season of edible maturity of summer-apple varieties suited to growing in the Middle Atlantic States.*

Variety.	Use.	New Jersey section.		Chesapeake peninsula section.		Virginia section.		North Carolina section.	
		Relative importance.	Season begins about—	Relative importance.	Season begins about—	Relative importance.	Season begins about—	Relative importance.	Season begins about—
Alexander	km	3	July 25						
Bachelor Blush	km	3	Aug. 25						
Benoni	d	3	Aug. 20			3	July 10		
Bonum	d					3	Sept. 1	1	Aug. 2
Bough	d	2	July 10	2	July 10				
Celestia	dkm			3	Sept. 5	3	Sept. 1		
Champlain	km	2	July 25	2	July 25				
Colton	km			2	July 10				
Cornell	d	3	Aug. 15						
Early Edward	d	3	July 25	3	July 25				
Early Harvest	dk	2	July 5	2	July 5	1	June 25	1	June 1
Early Joe	d	3	July 25	3	July 25				
Early Ripe	km			1	July 1			3	June 1
Early Strawberry	d	2	July 15	2	July 15				
English Codlin	km	2	July 25						
Fanny	k	3	...do...	3	July 25				
Golden Sweet	dk			3	...do...			3	July 1
Gravenstein	dkm	1	Aug. 5	1	Aug. 5	1	July 25		
Horse	k							1	July 1
Jefferis	d			3	Aug. 1	3	July 25		
Jersey Sweet	d			3	Aug. 15	3	Aug. 10		
July	km			1	July 10				
Keswick	km	3	July 25						
Lowell	dk	3	Aug. 1						
Maiden Blush	km	1	Aug. 15	1	Aug. 10	1	Aug. 1		
Metz	k							2	July 2
Oldenburg	km	2	July 20	2	July 20	3	July 15		
Orange Pippin	km	3	July 25						
Primate	d	3	July 15						
Randolph	km			2	July 20				
Red Astrachan	km	1	July 10	1	July 5	1	July 1	1	June 2
Red June	dm			2	July 10	1	...do...	1	June 1
Roadstown	km	2	Aug. 1						
Smokehouse	dkm	3	Sept. 10			1	Sept. 1		
Starr	km	1	July 15						
Summer Hagloe	km	1	July 20	1	July 20				
Summer Rose	d	3	July 15	2	July 10				
Tetofski	km	3	...do...	3	July 15				
Wealthy	dkm	2	Aug. 1						
Williams	dkm	1	July 20	1	July 20			3	July
Yellow Transparent	dkm	1	July 5	1	July 1	1	June 20	1	June 1

In Table III several varieties are rated as of first importance i either the New Jersey or the Chesapeake peninsula section, but ar not mentioned as being grown at all in either of the other section The conditions in each section are sufficiently similar to suggest th probability that a variety which can be grown with a high degree o success in any one of them is at least a promising sort for trial i all of the others. The varieties referred to in this connection can b readily determined by reference to the above table.

Several sorts rated as 2 or 3 in the sections in which they are grown appear to possess sufficient merit for their season of ripening to warrant a more general planting of them. The more important of these varieties are Bachelor Blush, Celestia, English Codlin, Oldenburg, Primate, Roadstown, Smokehouse, and Wealthy.

In the discussion of varieties a number of sorts are mentioned which appear to be promising, but which are not sufficiently well known in these sections for them to have any particular rating in comparison with other varieties. A number of varieties are also included in the varietal discussion which are not in cultivation in any section of this region so far as is known, but which are sufficiently promising in other sections to suggest the probability of their being successfully grown in this region. These two groups of varieties comprise the following: Coffman, Cross, Dawes, Early Cooper, Glowing Coal, Hawthornden, Kane, Muster, Sandbrook, Summer Extra, Summer King, Thaler, Townsend, and Trenton Early.

PHENOLOGICAL RECORDS.

CHARACTER OF DATA.

Exact dates of the blossoming of varieties, the opening of the leaves, the ripening periods of the fruit, and its keeping qualities in different sections furnish valuable means for studying the adaptability of varieties when such data are accompanied by sufficient information concerning the age and condition of the trees or plants in question and the conditions under which they are grown. The latter should include climatological data.

Information regarding environment is essential to a correct interpretation of the varietal data just mentioned and also in order to make the data from one section fully comparable with those from another. The correlation of climatic and varietal data constitutes one feature of the science of phenology (a contraction of the word phenomenology). This science treats of the relationships of local climatic conditions and the periodical recurrence of the phenomena of plant life or, in a broader sense, of all living things, both plants and animals.

The phenological data presented in Table IV, relating to apples in New Jersey, Maryland, Delaware, Virginia, and North Carolina, recorded under the direction of the Bureau of Plant Industry by a large number of fruit growers located in different sections of these States, are appended for the purpose not only of disseminating the specific varietal information which has thus been recorded, but also because such data make possible comparisons with other sections from which important deductions may be made.

That these comparisons and deductions may be as complete and far-reaching as possible, the important varieties of apples of all

seasons grown in these States are included, as well as the earl ripening ones to which the subject-matter of the foregoing pag relates. For a similar reason, the range of observations includ the entire States, of which the region under discussion in the earli pages forms a part.

The climatological tables on pages 13 to 15, for the years 1902 1907, inclusive, which correspond to the years covered by the phen logical data below, should be carefully consulted in studying the data, since the latter are governed largely by the prevailing climat conditions.

A list of the names and addresses of those who have contribut the data presented in Table IV is given below. Each observer assigned a number. These appear in the first column in the li in numerical order. For convenience in indicating the approxima geographical location where the different records were made, t number representing the observer who made each one is plac before it in Table IV in the column headed "Observer's No."

The sequence of arrangement in Table IV is by States, from sou to north; under each State, it is alphabetically by counties, as a also the names of the post-offices and observers in each county. T order of the observations on each variety is also from south to nort in accordance with the approximate latitude at which each observ tion was made.

PHENOLOGICAL OBSERVERS.

In the following list are included the names and post-office a dresses of the fruit growers who have furnished the phenologic data presented in this bulletin:

List of observers who have furnished the phenological data included in this bulletin.

NORTH CAROLINA.

Observer's No.	Grower.	Post-office.	County.
1	J. C. Cowan	Asheville	Buncombe.
2	T. P. Gaston	Candler	Do.
3	F. B. Barnhardt	Concord	Cabarrus.
4	J. A. Dula	Lenoir	Caldwell.
5	J. Hatley	Sawmill	Do.
6	J. S. Breece	Fayetteville	Cumberland.
7	M. L. Furr	Mount Holly	Gaston.
8	J. J. Phoenix	Greensboro	Guilford.
9	John Farrior	Waynesville	Haywood.
10	G. D. Green	....do	Do.
10a	....do	....do	Do.
10b	....do	....do	Do.
10c	....do	....do	Do.
10d	....do	....do	Do.
11	C. Oates	Bear Wallow	Henderson.
12	J. F. Livingston	Fletcher	Do.
13	Mark Moore	Horseshoe	Do.
14	J. D. Woody	Wilmington	New Hanover.
15	W. T. Lindsey	Tryon	Polk.
15a	J. F. Davenport	Cherry	Washington.
16	J. L. Kincaid	Boone	Watauga.
17	C. G. Hodges	Sands	Do.

List of observers who have furnished the phenological data included in this bulletin—Con.

VIRGINIA.

Observer's No.	Grower.	Post-office.	County.
18	J. E. Smith	Cismont	Albemarle.
19	Walter Whately	Crozet	Do.
20	J. W. Apperson	Yancey Mills	Do.
21	T. J. Cunningham	Amherst	Amherst.
22	W. F. Gilkeson	Fishersville	Augusta.
23	H. F. Deffenbaugh	Staunton	Do.
24	J. D. Keeler	Bedford City, R. F. D	Bedford.
25	J. D. Lowry	....do	Do.
26	J. F. Deboe	Bodycamp	Do.
27	W. H. Taylor	Colemans Falls	Do.
28	T. J. Holdren	Thaxton, R. F. D	Do.
29	M. L. Hatcher	Penicks, R. F. D	Do.
30	R. L. Dearing	Stewartsville	Do.
31	C. E. Layman	Troutville	Botetourt.
32	E. W. Byrd	Berryville	Clarke.
33	Hampton Agricultural and Normal Institute.	Hampton	Elizabeth City.
34	E. B. Whaley	Pender	Fairfax.
35	J. A. McLaughlin	Morrisville	Fauquier.
36	Joseph Wetsel	Wetsels	Greene.
37	A. B. Davis	Purcellville	Loudon.
38	H. L. Price	Blacksburg	Montgomery.
39	J. C. Carmody	Christiansburg	Do.
40	J. J. Shoemaker	....do	Do.
41	W. B. MacGregor	Avon	Nelson.
42	Withers Massie	Massies Mill	Do.
43	R. L. Hughes	Nellysford	Do.
44	J. E. Purvis	Oakridge	Do.
44a	W. M. Boyd	Roseland, R. F. D	Do.
45	James Dickie	....do	Do.
46	E. W. Rogers	Jennings	Nottoway.
47	Geo. W. Via	Woolwine	Patrick.
48	J. B. Johnson	Manassas	Prince William.
49	R. C. Booth	Dublin	Pulaski.
50	C. H. Constable	Warsaw	Richmond.
51	J. Coles Terry	Bent Mountain	Roanoke.
52	E. L. Wright	Vinton	Do.
53	W. J. Cowger	Dayton	Rockingham.
54	G. A. Copp	Strasburg	Shenandoah.
55	J. H. Pifer	....do	Do.
56	L. B. Moore	Arco	Warren.

MARYLAND.

Observer's No.	Grower.	Post-office.	County.
57	Saml. Garner	Annapolis	Anne Arundel.
58	Jesse Smith	Linwood	Carroll.
59	Geo. Balderston	Colora	Cecil.
60	W. R. Grosh	Elkton	Do.
60a	....do	....do	Do.
61	J. M. Andrews	Hurlock	Dorchester.
62	C. L. Vail	Forest Hill	Harford.
63	Thomas Tobin	Harford Furnace	Do.
64	L. E. Hollingsworth	Joppa	Do.
65	J. S. Harris	Worton, R. F. D	Kent.
66	F. H. Harper	Stillpond	Do.
67	W. S. Maxwell	....do	Do.
68	R. B. Thomas	Ednor	Montgomery.
69	W. I. Walker	Millington	Queen Anne.
70	Frisby Smith	Hancock	Washington.
71	F. E. Matthews	Pocomoke City	Worcester.

DELAWARE.

Observer's No.	Grower.	Post-office.	County.
72	F. C. Bancroft	Camden	Kent.
73	C. G. Brown	....do	Do.
74	E. G. Packard	Dover	Do.
75	John Heyd	Felton	Do.
76	F. M. Soper	Magnolia	Do.
77	S. H. Derby	Woodside	Do.
78	G. B. Graeff	Bridgeville	Sussex.

List of observers who have furnished the phenological data included in this bulletin—Con.

NEW JERSEY.

Observer's No.	Grower.	Post-office.	County.
79	T. Chalmers	Folsom	Atlantic.
80	A. Hansell	Burlington	Burlington.
81	W. P. Pray	Dobbins	Do.
82	J. S. Collins	Moorestown	Do.
83	S. C. De Cou	.....do	Do.
84	G. L. Gillingham	.....do	Do.
85	A. L. Ritchie	Riverton	Do.
86	H. G. Taylor	.....do	Do.
87	H. L. Sabsovich	Woodbine	Cape May.
88	G. W. Gould	Montclair	Essex.
89	A. T. Repp	Glassboro	Gloucester.
90	C. G. Kirby	Mullica Hill	Do.
91	S. S. Budd	Thorofare	Do.
92	J. F. Brown	Princeton	Mercer.
93	H. E. Hale	.....do	Do.
94	I. J. Blackwell	Titusville	Do.
95	J. T. Robbins	Allentown	Monmouth.
96	W. H. Reid	Tennet	Do.
97	C. M. Rorer	Cassville	Ocean.
98	W. H. Skillman	Bellemead	Somerset.
99	A. F. Randolph	Boundbrook	Do.
100	W. J. Logan	Somerville	Do.
101	W. S. Little	Sussex	Sussex.
102	A. A. Miller	.....do	Do.
103	H. B. De Kay & Son	Vernon	Do.
104	M. E. Vass	Blairstown	Warren.

TABLE IV.—*Phenological records—Apples.*

ARKANSAS. Synonym: *Mammoth Black Twig.*

Observer's number.	State.	Approximate latitude.	Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
		° ′														
33	Virginia	37 0	5	SW.	Sandy loam	1903	7	Apr. 10	Apr. 18	Apr. 5	Apr. 25	June –		Oct. 27		
33	do	37 0	5	SW.	do	1904	8	Apr. 22	Apr. 30	Apr. 20	Apr. 5	June 23	Sept. 15	Oct. 17	Oct. 1	Oct.
38	do	37 15	2,170	NW.	Limestone clay	1902	13	Apr. 26	May 3	Apr. 8	Apr. 10			Sept. 24		
38	do	37 15	2,170	NW.	do	1903	14	Apr. 10	Apr. 18	Apr. 5	Mar. 27		Oct. 1	Sept. 14		Mar.
38	do	37 15	2,170	NW.	do	1904	15	May 2	May 7	May 16	Apr. 19	June 20		Oct. 15		
28	do	37 20	1,000	N.	Sandy loam	1904	5	May 10	May 16	May 7			Oct. 20		Oct. 20	Late.
28	do	37 20	1,000	N.	do	1907	8	Mar. 27	Apr. 24	Mar. 7	Mar. 20	June 18	Oct. 8		Oct. 25	Do.
31	do	37 25	1,400	NW.	Gravelly loam	1902	6	Apr. 20	do	Apr. 8	Apr. 20	July –	Sept. 25		Oct. –	Do.
54	do	39 0	1,000	NE.	Sandy loam	1903	10	Apr. 10	Apr. 22	Apr. 5	Apr. 1	June 10	Oct. 1		Dec. 6	June.
68	Maryland	39 10	550	S.	Porous clay	1906	9	Apr. 19	Apr. 30	May 10	Apr. 14		Oct. 10	Oct. 12	Jan. 1	Do.
90	New Jersey	39 45	125	SW.	Gravelly	1907	10	May 6	May 12	Apr. 21						Late.
83	do	39 55	50	None.	Sandy	1906		Apr. 24	May 8							
83	do	39 55	50	None.	do	1907		May 6	May 3							

BALDWIN.

Observer's number.	State.	Approximate latitude.	Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
4	North Carolina	35 50	1,200	S.	Sandy loam	1904	20	Apr. 15	May 1				Sept. –		Aug. –	Sept.
4	do	35 50	1,200	S.	do	1905		do							do	
47	Virginia	36 45	1,600	S.	Porous loam	1905	10	May 1	May 10	May 1						
38	do	37 15	2,170	NW.	Limestone clay	1902	13	Apr. 28	May 2	Apr. 18	Apr. 8			Oct. 14		
38	do	37 15	2,170	NW.	do	1903	14	Apr. 16	Apr. 26	Apr. 5	Mar. 27		Sept. 15	Sept. 14	Oct. 1	Nov.
38	do	37 15	2,170	NW.	do	1904	15			May 16	Apr. 22	June 20		Oct. 15		
29	do	37 20	1,200	SE.	Porous loam	1903	10	Apr. 4	Apr. 10	Apr. 6	Apr. 12		Sept. 10		Aug. 1	Dec.
27	do	37 30	1,000	NE.	Clay loam	1902	26	Apr. 18	Apr. 21	Mar. –	Apr. 9		Sept. 20	Nov. –	Oct. –	Do.
36	do	38 15	650		Sandy loam	1902	18	do	do	May 3	Apr. 20			Oct. 17		
53	do	38 25	1,400	W.	Gravelly loam	1903	17	Apr. 11	Apr. 20		Apr. 9		Sept. –		Nov. –	Jan.
53	do	38 25	1,400	W.	do	1904	18	Apr. 20	Apr. 26		Apr. 3		do	Oct. –	Sept. –	Do.
53	do	38 25	1,400	W.	do	1906	20	Apr. 26	May 2	May 11	Apr. 17		do	Oct. 12	do	Dec.
35	do	38 30	400	NE.	Cecil clay	1902	5	May 4	May 8	Apr. 15	Apr. 16	Aug. 22		Oct. 22		
35	do	38 30	400	NE.	do	1903	6			Apr. 5	Mar. 22	Aug. 1		Oct. 18		
35	do	38 30	400	NE.	do	1904	7			Apr. 23	Apr. 7	July 19		Sept. 23		
35	do	38 30	400	NE.	do	1905	8	Apr. 17	Apr. 22	Apr. 20	Mar. 31	July 10	Sept. 10	Oct. 13		
35	do	38 30	400	NE.	do	1906	9			May 10	Apr. 16	July 26		Oct. 12		
48	do	38 45	375	SE.	Porous loam	1903	15	Apr. 9	Apr. 12	Apr. 5	Apr. 15	June 30	Aug. 20	Oct. 25	Oct. 20	Nov.
48	do	38 45	375	SE.	do	1905	17	Apr. 20	Apr. 24		Apr. 20					

TABLE IV.—*Phenological records—Apples*—Continued.

BALDWIN—Continued.

Observer's number.	State.	Approximate latitude. °	'	Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking.)	Date first fall frost.	Date fit for use.	Keeps until—
48	Virginia	38	45	375	SE.	Porous loam	1906	33	Apr. 25	Apr. 27	May 11	May 1			Oct. 11	Aug. 20	Nov.
48	do.	38	45	375	SE.	do.	1907		Apr. 26	Apr. 28	Apr. 20			Sept. 20	Oct. 13		Do.
56	do.	38	50	950	NW.	Porous clay	1907	10	Apr. 15	Apr. 25	Apr. 10	Apr. 15	Apr. 25	Sept. 1			Jan.
54	do.	39	0	1,000	NE.	Porous loam	1902	8	Apr. 24	Apr. 29	Apr. 14	Apr. 16	June 15	Sept. 20		Sept. 20	
54	do.	39	0	1,000	NE.	do.	1903	9	Apr. 18	Apr. 24	Apr. 5	Apr. 1	June 10	Sept. 10		do.	Dec.
54	do.	39	0	1,000	NE.	do.	1904	10	May 6	May 10	Apr. 20	Apr. 30	do.				
54	do.	39	0	1,000	NE.	do.	1905	11	Apr. 24	Apr. 29	Apr. 19	Apr. 11	do.	Sept. 20			
54	do.	39	0	1,000	NE.	do.	1906	18	Apr. 26	Apr. 30	May 8	Apr. 18	do.	Sept. 25		Oct. 1	Mar.
54	do.	39	0	1,000	NE.	do.	1907	19	Apr. 25	do.	Apr. 23	Apr. 3	June 15	Oct. 1		Dec. -	June.
72	Delaware	39	10	70	None.	Sandy loam	1902	30	do.	Apr. 28				Sept. 30	Oct. 20	Nov. 1	
73	do.	39	10	70	None.	do.	1902	20	Apr. 28	May 4		Apr. 12		Sept. 1		Sept. 15	Nov.
64	Maryland	39	25	225		Stony loam	1905	40	Apr. 23	Apr. 28	Apr. 19	Apr. 23	Sept. 1	Sept. 15	Oct. 19	Sept. 1	Jan.
64	do.	39	25	225		do.	1906	60	Apr. 29	May 3	May 10	Apr. 30	Aug. 30		Oct. 11		
63	do.	39	30	150	N.	Clay loam	1907	20	May 1	May 8	May 12	Apr. 16	Aug. 6	Oct. 8	Oct. 15	Sept. 15	Mar.
62	do.	39	35	500	E.	Loam	1905	45	Apr. 26	May 4				Oct. 15		Dec. 15	
62	do.	39	35	500	E.	do.	1906		Apr. 28	May 2	May 11			Oct. 1			
60	do.	39	35	75	SW.	Heavy loam	1902	10	Apr. 30	do.	May 28	Apr. 25	July 15	Sept. 15	Nov. 15	Late	
60	do.	39	35	75	SW.	do.	1904	12	May 7	May 10	May 11	Apr. 30	June 29	Oct. 5	Sept. 17		
79	New Jersey	39	35	90	NW.	Gravelly loam	1902	50	Apr. 24	Apr. 29	Apr. 15	Apr. 20		Sept. 15	Oct. 22	Sept. 15	
89	do.	39	40	150	None.	Porous loam	1904	27	May 6	May 10	Apr. 17	May 2	June 15	do.	Sept. 25	Jan. 1a	
90	do.	39	45	125	SW.	Gravelly	1907	10	do.	do.	Apr. 21						
91	do.	39	50	150			1906	35	Apr. 22	May 1		Apr. 14	July 20	Oct. 15		Sept. 10	Feb.
83	do.	39	55	50	None.	Sandy loam	1902	20	Apr. 24	Apr. 30							
80	do.	40	5	50	N.	Porous loam	1904	35	May 7	May 9	Apr. 24		June 1	Sept. 25	Oct. 10	Sept. 10	Apr.
80	do.	40	5	50	N.	do.	1905	50	Apr. 30	May 5	Apr. 19	Apr. 20	June 7	Sept. 28	Oct. 15		Do.
80	do.	40	5	50	N.	do.	1907	40	May 6	May 14	Apr. 20	Apr. 10	June 20	Oct. 4			
96	do.	40	15	90	N.&S.	Clay loam	1904	25	May 9	do.		May 6		Sept. 14	Sept. 17	Sept. 14	Jan.
96	do.	40	15	90	N.&S.	do.	1905	26	May 1	May 8		Apr. 20		Sept. 12	Oct. 18	Sept. 15	Do.
96	do.	40	15	90	N.&S.	do.	1906	27	do.	do.		do.		do.		Sept. 12	Do.
92	do.	40	15	200	S.	do.	1906	35	Apr. 26	May 4	May 10			Oct. 15	Oct. -	Oct. 15	Feb.
92	do.	40	15	200	S.	do.	1907	36	May 10	May 15	May 22	Apr. 27	June 12	Oct. 1		Dec. -	Do.
94	do.	40	20	125	SW.	Sandy loam	1902	38	Apr. 29	May 4	Apr. 28	Apr. 20	June 27	do.	Oct. 10	Sept. 20	Sept.
94	do.	40	20	125	SW.	do.	1904	40	May 7	May 11		Apr. 28	July 16	Sept. 1	Sept. 20	Sept. 10	Do.
94	do.	40	20	125	SW.	do.	1905	41	May 2	May 7	Apr. 19			Sept. 15		Sept. 1	Oct.
94	do.	40	20	125	SW.	do.	1906	42	do.	May 9	May 12	Apr. 20	June 5	Sept. 20			
94	do.	40	20	125	SW.	do.	1907	43	May 13	May 10		Apr. 27	July 4	do.	Oct. 20	Oct. -	Oct.
99	do.	40	35	40	NW.	do.	1907		May 10		May 12	May 1		Oct. 15	Oct. 5		Jan.
100	do.	40	35	600	N.	Clay loam	1903	19	Apr. 22			Apr. 7					

100	....do	40	38	600	W.	....do	1904	20	May 8	May 16	Apr. 22	May 1	....	....	....	....	....
88	....do	40	50	500	E.	Sandy loam	1907	16	...do	May 12	Apr. 25	May 14	....	Oct. 15	Oct. 10	Nov. 25	Mar.
104	....do	41	0	600	None.	Clay loam	1904	12	May 11	May 16	Apr. 23	May 2	July 2	Oct. 8	Sept. 22	Jan. -	Do.
104	....do	41	0	600	None.	....do	1905	14	May 7	May 11	Apr. 24	Apr. 25	July 3	Oct. 5	Oct. 22	Dec. -	Apr.
104	....do	41	0	600	None.	....do	1906	15	May 9	May 14	May 11	Apr. 22	July 2	Oct. 8	Oct. 12	...do	Mar.
104	....do	41	0	600	None.	....do	1907	16	May 15	May 20	May 12	Apr. 27	July 3	Oct. 15	Oct. 25	...do	Apr.
101	....do	41	10	550	SE.	Gravelly	1904	11	May 8	May 18	Apr. 23	Apr. 30	....	....	Sept. 22	....	....
102	....do	41	10	800	None.	Sandy loam	1904	25	May 12	...do	....	....	....	....	....	....	....
102	....do	41	10	800	None.	....do	1905	26	May 7	May 12	....	....	....	....	....	Dec. -	Apr.
103	....do	41	15	400	SW.	....do	1904	......	May 12	May 18	May 5	....	....	Sept. 1	....	....	....

BEN DAVIS.

6	North Carolina	35	5	200	None.	Sandy	1902	......	Apr. 6	Apr. 18	....	Mar. 23	....	....	....	....	....
6	....do	35	5	200	None.	....do	1904	......	Mar. 23	Mar. 31	....	....	....	....	....	....	....
7	....do	35	20	700	None.	Loam	1905	10	Mar. 25	Apr. 5	Apr. 17	Mar. 18	....	....	Oct. 11	....	....
11	....do	35	25	1,990	SE.	Porous loam	1904	15	Apr. 30	May 5	Apr. 21	May 5	....	Sept. 23	Oct. 24	Nov. 1	Jan.
11	....do	35	25	1,990	SE.	....do	1905	12	May 1	May 10	May 6	May 10	....	Sept. 5	Oct. 18	....	....
11	....do	35	25	1,990	SE.	....do	1906	20	Apr. 12	Apr. 20	May 10	Apr. 5	....	Oct. 10	Oct. 10	Nov. 1	Jan.
11	....do	35	25	1,990	SE.	....do	1907	9	Apr. 4	Apr. 30	Apr. 2	Apr. 20	....	....	....	....	Mar.
12	....do	35	25	2,128	W.	....do	1902	18	Apr. 26	May 2	Apr. 5	Apr. 23	July 1	Sept. 20	Oct. 15	Oct. 1	Feb.
12	....do	35	25	2,128	W.	....do	1903	19	Apr. 11	Apr. 16	Apr. 6	Apr. 24	....	....	....	....	....
12	....do	35	25	2,128	W.	....do	1904	20	Apr. 20	May 2	Apr. 11	May 14	Aug. 8	Oct. 1	Oct. 15	Nov. 15	Feb.
12	....do	35	25	2,128	W.	....do	1905	21	Apr. 8	Apr. 16	Apr. 7	Apr. 23	Aug. 1	Sept. 25	Oct. 14	Nov. 1	Jan.
2	....do	35	30	2,900	E.	Clay loam	1904	8	Apr. 17	Apr. 28	Apr. 20	Apr. 7	....	....	...do	....	....
2	....do	35	30	2,900	E.	....do	1905	9	Apr. 5	Apr. 13	Apr. 18	Apr. 3	July 24	Nov. 12	Oct. 17	....	....
10	....do	35	30	2,875	SW.	....do	1902	14	Apr. 29	May 8	Apr. 1	May 6	July 28	Oct. 15	Oct. 15	Dec. 15	Mar.
10	....do	35	30	2,875	SW.	....do	1903	7	Apr. 1	Apr. 12	Apr. 28	Apr. 5	July 15	Oct. 20	Oct. 25	Dec. 25	Apr.
10	....do	35	30	2,875	SW.	....do	1904	8	Apr. 16	Apr. 25	Apr. 1	Mar. 23	June 30	Oct. 15	Oct. 16	Nov. 1	Feb.
10	....do	35	30	2,875	SW.	....do	1905	9	....	....	Mar. 10	Mar. 28	July 2	Oct. 20	....	Dec. 15	Do.
10a	....do	35	30	3,300	NE.	Porous loam	1902	6	Apr. 21	Apr. 27	Apr. 15	Apr. 24	July 30	...do	Oct. 5	Dec. 20	Mar.
10b	....do	35	30	3,500	SE.	....do	1902	12	May 1	May 10	Apr. 20	May 7	July 29	...do	Oct. 3	...do	Do.
10c	....do	35	30	4,000	NE.	Clayey loam	1902	9	...do	May 8	Apr. 25	May 9	July 30	...do	...do	Feb. -	Do.
10d	....do	35	30	4,500	SE.	Sandy loam	1902	12	Apr. 25	May 3	Apr. 22	....	...do	Oct. 25	Oct. 1	Dec. 20	Feb.
10d	....do	35	30	4,500	SE.	....do	1903	13	May 1	May 12	Apr. 28	May 4	July 18	Oct. 10	Oct. 5	Dec. 10	May.
1	....do	35	35	2,300	S.	Loam	1904	4	Apr. 15	Apr. 28	Apr. 20	Apr. 3	....	....	Oct. 15	....	....
17	....do	36	15	3,000	SE.	Clay loam	1904	8	Apr. 30	May 8	May 3	May 5	....	Oct. 7	Oct. 11	Jan. 15	May.
47	Virginia	36	45	1,700	SE.	Black loam	1905	......	Apr. 15	May 1	May 1	....	....	Sept. 20	....	Oct. 20	Apr.
33	....do	37	0	5	None.	Sandy loam	1904	8	Apr. 21	Apr. 30	Apr. 20	Apr. 5	June 23	Aug. 20	Oct. 17	....	....
49	....do	37	5	....			1907	11	Apr. 23	May 3	...do	Apr. 28	....	Oct. 5	Oct. 15	Sept. 15	May.
39	....do	37	10	2,000	NW.	Dark loam	1902	10	Apr. 26	May 1	May 18	Apr. 20	....	Oct. 10	Sept. 10	Dec. 25	Mar.
40	....do	37	10	2,400	SE.	Porous loam	1907	8	Apr. 15	Apr. 30	....	Apr. 5	....	....	....	....	....
26	....do	37	15	900	N.	Sandy loam	1902	15	Apr. 19	Apr. 25	....	....	....	....	....	....	....
26	....do	37	15	900	N.	....do	1903	16	Apr. 4	Apr. 11	....	....	....	Sept. 10	....	Sept. 15	Nov.
38	....do	37	15	2 170	NW.	Limestone clay	1902	13	Apr. 26	May 3	Apr. 18	Apr. 12	....	Sept. 25	Sept. 14	....	....
38	....do	37	15	2,170	NW.	....do	1903	14	Apr. 25	Apr. 30	Apr. 5	Mar. 30	....	Sept. 30	...do	....	....
38	....do	37	15	2,170	NW.	....do	1904	15	May 7	May 10	May 16	Apr. 23	June 22	....	Oct. 15	....	....
28	....do	37	20	1,000	N.	Sandy loam	1904	8	May 15	....	May 7	....	....	Oct. 20	....	Oct. 20	Late.

a From cold storage.

TABLE IV.—*Phenological records—Apples*—Continued.

BEN DAVIS—Continued.

Observer's number.	State.	Approximate latitude.	Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking.)	Date first fall frost.	Date fit for use.	Keeps until—
		° ′														
28	Virginia	37 20	1,000	N.	Sandy loam	1905	9	Apr. 12	Apr. 20	Mar. 28	Apr. 3	June 15	Sept. 24		Oct. 5	Late.
28	do	37 20	1,000	N.	do	1906	10	Apr. 17	Apr. 23	May 29	Apr. 2	July 10		Nov. 20		
25	do	37 20	1,000	SE.	Cecil clay	1902	10	Apr. 15	Apr. 20	May 20	Apr. 15	July 15	Oct. 15	Oct. 20	Jan. -	Mar.
25	do	37 20	1,000	SE.	do	1903	11	Apr. 20	May 1	Apr. 20	Apr. 20	July 20	Oct. 10	Oct. 15	Dec. -	Do.
25	do	37 20	1,000	SE.	do	1904	12	May 1	May 10	May 5	May 1	July 10	do	Oct. 10	do	Do.
25	do	37 20	1,000	SE.	do	1905	13	Apr. 25	May 5	Apr. 15	Apr. 25	July 20	Oct. 20	Oct. 20	do	Do.
29	do	37 20	1,000	SE	do	1903	4	Apr. 4	Apr. 25	Apr. 6	Apr. 15		Sept. 15		Sept. -	Jan.
31	do	37 25	1,400	NW.	Porous loam	1902	6	Apr. 21	Apr. 24	Apr. 8	Apr. 21	July -	Sept. 25		Nov. 4	Late.
27	do	37 30	1,000	NE.	Clay loam	1902	26	Apr. 19	Apr. 22	Mar. -	Apr. 9		Sept. 20	Nov. -	Oct. -	Dec.
27	do	37 30	1,000	NE.	do	1904	38	Apr. 18	do	Apr. 22			Sept. 15	Oct. 26	Sept. -	Nov.
44	do	37 45	625	SW.	Loam	1904	12	Apr. 22	Apr. 26	Apr. [a]	Apr. 4	June 15				
50	do	37 55	200	E.&W.	Sandy loam	1902	15	Apr. 17	Apr. 23	Apr. 9	Apr. 10		Oct. -	Oct. 30	Oct. -	Dec.
50	do	37 55	200	E.&W.	do	1903	16	Mar. 29	Apr. 3		Apr. 5		do		do	
50	do	37 55	200	E.&W	do	1904	17	Apr. 20	Apr. 25	Apr. 6	Apr. 25		Oct. 20	Sept. 7	do	
50	do	37 55	200	E.&W.	do	1905	18	Apr. 12	Apr. 16	Apr. 19	Apr. 16		Oct. 1	Oct. 22	do	Oct.
50	do	37 55	200	E.&W.	do	1906	19	Apr. 15	Apr. 25	May 11	Apr. 25		Oct. 20		Nov. -	Dec.
71	Maryland	38 5	20	SE.	Clay loam	1902	8		Apr. 29		Apr. 12		do		Nov. -	Do.
19	Virginia	38 5	900	S.	Cecil clay	1905	14	Apr. 14	Apr. 22	Apr. 19	Apr. 1		Sept. 1	Oct. 7		
23	do	38 10	1,400	N.	Porous loam	1907	8	Apr. 23	May 1	May 18	do	July 10	Oct. 8	Oct. 13	Dec. -	May.
22	do	38 10	1,200	NE.	do	1907	20	do	Apr. 30	May 22	Mar. 28		Oct. 15	Oct. 9	Feb. 1	Apr.
36	do	38 15	650		Sandy loam	1902	15	Apr. 19	Apr. 24	May 3	Apr. 18		Oct. 17			
53	do	38 25	1,400	W.	Porous loam	1902	16	Apr. 28	May 2		Apr. 17		Sept. 30		Nov. -	Feb.
53	do	38 25	1,400	W.	do	1903	17	Apr. 9	Apr. 20		Apr. 9		Oct. -		Dec. -	Do.
53	do	38 25	1,400	W.	do	1905	19	Apr. 22	Apr. 27	Apr. 24	Apr. 4		Oct. 1	Oct. -	Oct. -	Do.
53	do	38 25	1,400	W.	do	1906	20	Apr. 27	May 3	May 11	Apr. 18	July -	do	Oct. 8	do	Do.
35	do	38 30	400	NE.	Clayey	1902	15	Apr. 22	Apr. 26	Apr. 15	Apr. 9	Aug. 18	Sept. 26	Oct. 22		Mar.
35	do	38 30	400	NE.	do	1903	16	Apr. 2	Apr. 12	Apr. 5	Mar. 21	Aug. 6	Oct. 1	Oct. 18		Do.
35	do	38 30	400	NE.	do	1904	17	Apr. 30	May 5	Apr. 23	Apr. 8	July 23	Sept. 26	Sept. 23		Do.
35	do	38 30	400	NE.	do	1905	18	Apr. 18	Apr. 20	Apr. 20	Apr. 30	July 18		Oct. 13		Do.
35	do	38 30	400	NE.	do	1906	19	Apr. 22	Apr. 28	May 10	Apr. 9	July 28		Oct. 12	Sept. 1	Do.
61	Maryland	38 40	45	None.	Sandy loam	1907	15	Apr. 15	do							
78	Delaware	38 45	50	SE.	do	1904	21	Apr. 29	May 4	Apr. 22	Apr. 13					
34	Virginia	38 45	300	W.	Clay loam	1902	13	Apr. 18		May 30[b]						
48	do	38 45	375	SE.	Porous loam	1903	15	Apr. 8	Apr. 11	Apr. 5	Apr. 15	July 2	Sept. 15	Oct. 25	Jan. -	Mar.
48	do	38 45	375	SE.	do	1905	17	Apr. 23	Apr. 26	Apr. 19	Apr. 21					
48	do	38 45	375	SE.	do	1906	30	Apr. 26	Apr. 28	May 11	Apr. 29			Oct. 11	Sept. 20	Feb.
48	do	38 45	375	SE.	do	1907		Apr. 22	Apr. 25	Apr. 20				Oct. 13		

56	....do	38	50	950	NW.	Clay loam	1907	10	Apr. 20	Apr. 30	Apr. 10	Apr. 20		Sept. -		Jan. -	Apr.
54	....do	39	0	1,000	NE.	Porous loam	1902	14	Apr. 23	Apr. 26	Apr. 14	Apr. 14	June 15	Oct. 1		Nov. -	Late.
54	....do	39	0	1,000	NE.	....do	1903	15	Apr. 6	Apr. 20	Apr. 15	Mar. 27	June 10	...do		Dec. -	June.
54	....do	39	0	1,000	NE.	....do	1904	16	May 2	May 7	Apr. 20	Apr. 21	...do				
54	....do	39	0	1,000	NE.	....do	1905	17	Apr. 17	Apr. 24	Apr. 19	Apr. 3	...do	Sept. 20		Dec. -	
54	....do	39	0	1,000	NE.	....do	1906	18	Apr. 24	Apr. 29	May 8	Apr. 17	...do	Oct. 1		Oct. -	Apr.
54	....do	39	0	1,000	NE.	....do	1907	19	Apr. 20	Apr. 25	Apr. 23	Mar. 29	June 15	...do		Dec. -	June.
55	....do	39	0	600	E.	....do	1907	14	Apr. 21	Apr. 24	May 9	Mar. 27		...do	Oct. 10	Mar. -	May.
57	Maryland	39	0	75	None.	Sandy	1907	15	Apr. 27	May 6	Apr. 18	Apr. 6					
68	....do	39	10	550	S.	Clay loam	1906	9	Apr. 21	May 2	May 10	Apr. 17		Oct. 1	Oct. 12		
32	Virginia	39	10	500	NW.	Red loam	1905	11	Apr. 23	Apr. 26	Apr. 18	Apr. 1	Apr. 18	Oct. 4		Dec. -	Mar.
32	....do	39	10	500	NW.	....do	1906	12	Apr. 26	Apr. 30	Apr. 25	Apr. 20	June 15	Oct. 1	Oct. 15	Jan. -	Do.
37	....do	39	10	600	NW.	Clay loam	1903	17	Apr. 17	Apr. 23							
87	New Jersey	39	15	40	SW.	Sandy loam	1902	10	Apr. 30	May 7		Apr. 24					
65	Maryland	37	20	75	None.	Gravelly loam	1902	7	Apr. 25	Apr. 28		Apr. 7		Oct. 15	Nov. -	Dec. -	
65	....do	37	20	75	None.	....do	1903	8	Apr. 15	Apr. 20		Apr. 1				Nov. -	Jan.
64	....do	39	25	225	SE.	Stony loam	1905	15	Apr. 25	Apr. 30	Apr. 19	Apr. 23		Oct. 15	Oct. 19	...do	Do.
64	....do	39	25	225	SE.	....do	1906	16	Apr. 29	May 1	May 10	May 1			Oct. 11		
64	....do	39	25	225	SE.	....do	1907	17	May 1	May 10	May 5	Apr. 28			Oct. 17		
63	....do	39	30	150	N.	Clay loam	1907	20	...do	May 6	May 12	Apr. 24	Aug. 6	Oct. 14	Oct. 14	Sept. 16	Mar.
62	....do	39	35	500	E.	Loam	1905	25	Apr. 26	May 4	May 5	Apr. 28			Oct. 17		
89	New Jersey	39	40	150	None.	Porous loam	1904	25	May 8	May 12	Apr. 17	May 4	June 15	Oct. 1	Sept. 25		Apr.[c]
90	....do	39	45	125	SW.	Gravelly	1907	10	May 5	May 9	Apr. 21						
91	....do	39	50				1906	3	Apr. 30	May 1		Apr. 14	July 20	Oct. 15		Oct. -	Apr.
82	....do	39	55	50	W.	Sandy loam	1902	6	Apr. 25	Apr. 30				Oct. 1		Sept. -	Dec.
84	....do	39	55	50	W.	Heavy loam	1902	20	...do	...do	Apr. 16	Apr. 20	Sept. 15	...do	Oct. 10	Dec. -	Feb.
84	....do	39	55	50	W.	....do	1903	21	Apr. 22	Apr. 28	May 2	Apr. 10	Aug. 30	...do	Oct. -	Oct. -	Do.
84	....do	39	55	50	W.	....do	1904	22	May 7	May 17		Apr. 23	Aug. 1	...do		Nov. -	Mar.
92	....do	40	15	200	S.	Clay loam	1906	35	Apr. 23	Apr. 30	May 10			Oct. 15	Oct. -	Oct. -	Feb.
92	....do	40	15	200	S.	....do	1907	36	May 11	May 16	May 22	Apr. 27	June 12	Oct. 1	...do	Nov. -	Mar.
96	....do	40	15	90	N.&S.	....do	1904	21	May 9	May 14		May 6		Sept. 18	Sept. 17	Jan. -	Apr.
96	....do	40	15	90	N.&S.	....do	1905	22	May 2	May 9	Apr. -	Apr. 22		Oct. 13	Oct. 18	...do	Do.
96	....do	40	15	90	N.&S.	....do	1906	23	...do	May 3	Apr. 18	Apr. 24		Oct. 18	...do	Dec. -	Do.
94	....do	40	20	125	S.	Sandy loam	1904		May 6	May 11		Apr. 29	July 16	Oct. 1	Sept. 20	...do	Mar.
94	....do	40	20	125	S.	....do	1906		May 3	May 8		Apr. 20	June 5	Oct. 20		Oct. -	
94	....do	40	20	125	S.	....do	1907		May 12	May 15		Apr. 26	July 4				
98	....do	40	30	600	S.	Red shale	1905	14	May 3	May 12	Apr. 16	Apr. 28		Sept. -	Sept. -		Mar.
88	....do	40	50	500	E.	Sandy loam	1907	16	May 8	...do	Apr. 25	May 14		Oct. 15	Sept. 10	Nov. -	Do.
104	....do	41	0	600	None.	Clay loam	1904	12	May 10	May 14	Apr. 23	May 2	July 6	Oct. 20	Sept. 22		
104	....do	41	0	600	None.	....do	1905	13	May 7	May 11	Apr. 24	Apr. 26	July 3	Oct. 12	Oct. 22	Feb. -	May.
104	....do	41	0	600	None.	....do	1906	14	May 9	May 14	May 11	...do	June 30	Oct. 13	Oct. 12	Mar. -	Do.
104	....do	41	0	600	None.	....do	1907	15	May 16	May 21	May 12	Apr. 27	July 1	Oct. 26	Oct. 25	...do	Do.
101	....do	41	10	550	SE.	Gravelly	1904	11	May 7	May 18	Apr. 23	Apr. 28			Sept. 22		

[a] Frost did much damage to the fruit.
[b] Frost seriously injured the fruit.
[c] From cold storage.

TABLE IV.—*Phenological records—Apples*—Continued.

Observer's number.	State.	Approximate latitude.	Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
		° ′														
					BONUM.											
6	North Carolina	35 5	200	None.	Sandy	1902	.....	Apr. 7	Apr. 17	....	Mar. 30	....	....	Sept. 14	....	....
16	....do	35 25	770	N.	....do	1905	8	Apr. 2	Apr. 9	Apr. 18	Mar. 20	May 16	....	Oct. 22	....	....
38	Virginia	37 15	2,170	NW.	Limestone clay	1902	13	Apr. 28	May 3	Apr. 8	Apr. 15	....	....	Sept. 14	....	....
31	....do	37 25	1,400	NW.	Gravelly loam	1902	12	Apr. 20	Apr. 24	...do....	Apr. 21	July -	Aug. 15	....	Aug. 15	Oct.
48	....do	38 45	375	SE.	Porous loam	1903	10	Apr. 8	Apr. 12	Apr. 5	Apr. 15	....	Sept. 1	Oct. 25	....	Dec.
					BOUGH.											
72	Delaware	39 10	70	None.	Sandy loam	1902	30	Apr. 23	Apr. 27	....	....	....	July 5	Oct. 20	July 5	....
96	New Jersey	40 15	90	N.&S.	Clay loam	1904	25	May 9	May 15	....	May 7	....	July 19	Sept. 17	July 25	....
94	....do	40 20	150	S.	Sandy loam	1902	38	Apr. 29	May 4	Apr. 28	Apr. 20	June 27	July 25	Oct. 10	July 20	....
94	....do	40 20	150	S.	....do	1906	.....	Apr. 30	...do....	....	Apr. 16	June 5	July 23	Oct. 14	Aug. 1	....
					CHENANGO.											
38	Virginia	37 15	2,170	NW.	Limestone clay	1903	12	Apr. 12	Apr. 21	Apr. 5	Mar. 27	....	....	Sept. 14	....	....
38	....do	37 15	2,170	NW.	....do	1904	13	May 2	May 8	May 16	Apr. 16	June 25	....	Oct. 15	....	....
					COLTON.											
38	Virginia	37 15	2,170	NW.	Limestone clay	1903	14	Apr. 10	Apr. 28	Apr. 5	Mar. 27	....	....	Sept. 14	....	....
38	....do	37 15	2,170	NW.	....do	1904	15	Apr. 30	May 11	May 16	Apr. 16	June 25	....	Oct. 15	....	....
37	....do	39 10	600	NW.	Clay loam	1903	17	Apr. 12	Apr. 17	....	....	....	....	....	....	....

EARLY HARVEST.

6	North Carolina	35	5	200	None.	Sandy	1904	......	Mar. 22	Mar. 28							
7	do	35	20	700	None.	Loam	1905	10	Mar. 25	Mar. 31	Apr. 17	Mar. 15			Oct. 11		
11	do	35	25	1,990	SE.	Porous loam	1904	15	Apr. 20	Apr. 28	Apr. 21	Apr. 25		June 20	Oct. 24		
11	do	35	25	1,990	SE.	do	1905	10	do	May 1	May 6	May 6		July 20	Oct. 18	July 1	Aug.
11	do	35	25	1,990	SE.	do	1906	8	Apr. 15	Apr. 25	May 10	Apr. 8		June 20		June 20	
11	do	35	25	1,990	SE.	do	1907	9	Mar. 30	Apr. 20	Apr. 20	Apr. 10			Oct. 13		
12	do	35	25	2,100	W.	do	1902	12	Apr. 18	Apr. 24	Apr. 5	Apr. 16	July 1	July 10	Oct. 15	July 1	Aug.
12	do	35	25	2,100	W.	do	1903	18	Mar. 28	Apr. 6	Apr. 6	Apr. 8					
12	do	35	25	2,100	W.	do	1904	19	Apr. 12	Apr. 20	Apr. 11	Apr. 21	July 26	July 18	Oct. 15	July 20	Aug.
12	do	35	25	2,100	W.	do	1905	20	Apr. 2	Apr. 10	Apr. 7	Apr. 12	July 15	July 14	Oct. 14	July 15	Do.
13	do	35	25	2,180	NE.	Clay loam	1905	16	Mar. 28	Apr. 20	Mar. 27	Mar. 25			Oct. 17	July 1	
13	do	35	25	2,180	NE.	do	1907	17	Apr. 3		Apr. 15[a]				Oct. 15		
2	do	35	30	2,900	E.	do	1904	......	Apr. 18	Apr. 28	Apr. 20				Oct. 14		
2	do	35	30	2,900	E.	do	1905	......	Apr. 2	Apr. 12	Apr. 18	Apr. 21	July 20	July 1	Oct. 17		
10	do	35	30	2,875	SW.	do	1902	......	Apr. 28	May 5	Apr. 1	May 4	July 30	July 25	Oct. 15	Aug. 1	Aug.
10[d]	do	35	30	4,500	SE.	Sandy loam	1903	12	May 1	May 10	Apr. 28	May 10	July 15	Aug. 15	do	Aug. 20	
1	do	35	30	2,300	S.	Porous loam	1902	10	Apr. 20	Apr. 26	Apr. 18	Apr. 12			do		Aug.
1	do	35	30	2,300	S.	do	1904	12	Apr. 12	Apr. 28	Apr. 20	Apr. 3	July 1		do		
1	do	35	30	2,300	S.	do	1905	13	Apr. 5	Apr. 15	Apr. 16	Mar. 27			Oct. 16		
1	do	35	30	2,300	S.	do	1906	10	Apr. 20	Apr. 26	Apr. 18	Apr. 12			Oct. 15		
15[a]	do	35	45	6	None.	Sandy	1907	......	Apr. 4	Apr. 22	Mar. 15	Apr. 5	Apr. 19		Oct. 20		
4	do	35	50	1,200	S.	Sandy loam	1904	12	Apr. 15							July 1	Aug.
4	do	35	50	1,200	S.	do	1905	13	do	May 1	Apr. 24						July.
16	do	36	10	3,250	S.	Clay loam	1904	18	May 8	May 15	Apr. 21	Apr. 26	July 5		Oct. 15	Aug. 10	Sept.
16	do	36	10	3,250	S.	do	1905	19	Apr. 23	May 1	May 16	Apr. 12	July 9	Aug. 10	Oct. 20		
17	do	36	15	3,000	SE.	do	1904	12	Apr. 28	May 5	May 3	May 1		do	Oct. 11	July 25	Sept.
47	Virginia	36	45	1,700	SE.	Black loam	1905	15	Apr. 10	Apr. 20	May 1			Aug. 1		Aug. 1	Do.
33	do	37	0	5	SW.	Sandy loam	1903	7			Apr. 5	Mar. 23		July 1	Oct. 27	July 1	July.
33	do	37	0	5	SW.	do	1904	8	Apr. 13	Apr. 26	Apr. 20	Mar. 28	June 23	July 3	Oct. 17	July 8	Do.
40	do	37	10	2,400	None.	Clay loam	1907	8	Apr. 7	Apr. 18	Apr. 1						
39	do	37	10	2,000	NW.	Loam	1902	4	Apr. 24	Apr. 28	May 18	Apr. 20			Sept. 10	July 25	Aug.
26	do	37	15	900	N.	Clay loam	1903	......	Apr. 1	Apr. 7			June 15	July 15		June 20	July.
46	do	37	15	500	S.	Sandy loam	1903	......	Mar. 30							do	Do.
38	do	37	15	2,170	NW.	Limestone clay	1903	13	Apr. 28	May 2	Apr. 18	Apr. 11			Sept. 14		
38	do	37	15	2,170	NW.	do	1904	14	Apr. 12	Apr. 29	Apr. 5	Mar. 26			do		
38	do	37	15	2,170	NW.	do	1905	15			May 16	Apr. 18	June 20		Oct. 15		
30	do	37	20	950	SE.	Clay loam	1902	27	Apr. 12	Apr. 25	Apr. 1	Apr. 15		July 10	Oct. 27	July 1	
30	do	37	20	950	SE.	do	1903	28	Apr. 2	Apr. 10	Apr. 6	Mar. 28		June 28	Nov. 2	July 10	
28	do	37	20	1,000	N.	do	1904	6	May 5	May 10	May 7	Apr. 14		June 20		June 20	July.
28	do	37	20	1,000	N.	do	1906	8	Apr. 10	Apr. 16	Mar. 29	Apr. 2	June 19		Nov. 20		
28	do	37	20	1,000	N.	do	1907	9	Apr. 13	Apr. 23	Mar. 7	Mar. 20	June 25		Nov. 4	July 16	Aug.
52	do	37	20	1,200	W.		1902	16	Apr. 16	Apr. 22		Apr. 7					
29	do	37	20	1,000		Clay loam	1903	25	Mar. 25	Apr. 6	Apr. 6	Apr. 10		June 24		June 10	July.
31	do	37	25	1,400	NW.	do	1902	12	Apr. 19	Apr. 23	Apr. 8	Apr. 20	July –	June 15		June 15	Do.
44	do	37	45	625	SW.	Loam	1904	12	Apr. 24		Apr. –	Apr. 4	June 15				
45	do	37	50		S.	do	1906	56	Apr. 12	Apr. 16	May 9	Apr. 5			Oct. 10		
50	do	37	55	200	E.&W.	Sandy loam	1902	15	Apr. 17	Apr. 23	Apr. 9	May 10		July –	Oct. 30	July –	Aug.

[a] Frost killed the entire crop.

		°	'														
50	Virginia	37	55	200	E.&W.	Sandy loam	1903	16	Mar. 28	Apr. 2		Apr. 5		July -		July 5	Aug.
50	do	37	55	200	E.&W.	do	1904	17	Apr. 20	Apr. 25	Apr. 6	Apr. 25		July 10	Sept. 7		
50	do	37	55	200	E.&W.	do	1905	18	Apr. 10	Apr. 14	Apr. 19	Apr. 14		July 5	Oct. 22	July 5	Aug.
50	do	37	55	200	E.&W.	do	1906	19	Apr. 15	Apr. 25	May 11	Apr. 25		July 10			Do.
50	do	37	55	200	E.&W.	do	1907	20			May -a						
20	do	38	0	700	S.	Clay loam	1905	30	Apr. 10	Apr. 14	Apr. 18	Mar. 29					
36	do	38	15	650		Sandy loam	1902	11	Apr. 18	Apr. 20	May 3	Apr. 18			Oct. 17		
35	do	38	30	400	NE.	Red clay	1902	2	Apr. 20	Apr. 24	Apr. 15	Mar. 29	Aug. 25		Oct. 22		
35	do	38	30	400	NE.	do	1903	3	Mar. 30	Apr. 5	Apr. 5	Mar. 20	Aug. 3	July 9	Oct. 18		July.
35	do	38	30	400	NE.	do	1904	4	Apr. 26	May 4	Apr. 23	Apr. 3	July 3		Sept. 23		
35	do	38	30	400	NE.	do	1905	5	Apr. 10	Apr. 18	Apr. 20	Mar. 31	July 11	July 8	Sept. 13		July.
35	do	38	30	400	NE.	do	1906	6	Apr. 19	Apr. 23	May 10	Apr. 8	July 14		Oct. 12		
78	Delaware	38	45	50	SE.	Sandy loam	1904	21	Apr. 25	May 4	Apr. 22	Apr. 3			•		
34	Virginia	38	45	300	W.	Clay loam	1902	13	Apr. 15		May 30b				Sept. 18		
48	do	38	45	375	SE.	Sandy loam	1903	15	Apr. 8	Apr. 11	Apr. 5	Apr. 15	June 28	July 10	Oct. 25		July.
48	do	38	45	375	SE.	do	1905	20	Apr. 21	Apr. 24	Apr. 19b	Apr. 21					
56	do	38	50	950	NW.	Clay loam	1907	4	Apr. 10	Apr. 20	Apr. 10	Apr. 15		July 1		July 1	
54	do	39	0	1,000	NE.	Sandy loam	1902	18	Apr. 23	Apr. 28	Apr. 14	Apr. 14	June 15	do		do	July.
54	do	39	0	1,000	NE.	do	1903	19	Apr. 9	Apr. 20	Apr. 5	Mar. 27	June 10	July 4		July 10	Do.
54	do	39	0	1,000	NE.	do	1904	20	May 1	May 6	Apr. 20	Apr. 19	do				
54	do	39	0	1,000	NE.	do	1905	21	Apr. 13	Apr. 22	Apr. 19	Apr. 4	do				
54	do	39	0	1,000	NE.	do	1906	22	Apr. 20	Apr. 27	May 8	Apr. 16	do	July 1		July 1	Aug.
54	do	39	0	1,000	NE.	do	1907	23	Apr. 16	Apr. 24	Apr. 23	Mar. 29	do	do		do	Do.
75	Delaware	39	0	60	None.	do	1906	20	Apr. 21	Apr. 27	Apr. 3	Apr. 18			Oct. 12		
72	do	39	10	70	None.	do	1902	25	Apr. 24	do				July 1	Oct. 20	July 1	
74	do	39	10	80	None.	Clay loam	1903	8	Apr. 16	Apr. 24	Apr. 6			July 10	Oct. 22	July 10	
67	Maryland	39	20	50	E.	Sandy loam	1903	30	Apr. 9	Apr. 13	do	Apr. 6		July 1	Oct. 26	July 15	
65	do	39	20	75		do	1902	7	Apr. 23	Apr. 27		Apr. 8		July 15	Nov. -	do	
65	do	39	20	75		do	1903	8	Apr. 9	Apr. 20		Mar. 26					
63	do	39	30	150	N.	Clay loam	1907	20	Apr. 29	May 6	May 12	Apr. 19	July 28	July 15	Oct. 15	July 10	July.
60	do	39	35	75	SW.	Heavy loam	1902	25	do	May 2	May 28	Apr. 25	July 5	July 8	Nov. 15	July 8	Do.
60	do	39	35	75	SW.	do	1903	26	Apr. 16	Apr. 23	Apr. 20	Apr. 4			Nov. -		
60	do	39	35	75	SW.	do	1904	27	May 7	May 10	May 11	Apr. 30	June 29	July 25	Sept. 17		July.
60a	do	39	35	125	SW.	Sandy loam	1902	29	Apr. 28	May 1	Apr. 20	Apr. 22		July 15	Nov. 15	July 10	Do.
60a	do	39	35	125	SW.	do	1903	30	Apr. 16	Apr. 23	do	Apr. 4	July 4		Nov. -		
60a	do	39	35	125	SW.	do	1904	31	May 2	May 8	Apr. 21	Apr. 26	June 25	July 25	Sept. 17		Aug.
79	New Jersey	39	35	90	NW.	Gravelly loam	1902	50	Apr. 21	Apr. 27	Apr. 15	Apr. 19		July 6	Oct. 22	July 6	July.
59	Maryland	39	40	300	None.	do	1902	15	Apr. 26	Apr. 28	do	Apr. 15	July 1	July 10		July 4	Do.
82	New Jersey	39	55	50	W.	Sandy loam	1902	20	Apr. 21	Apr. 27				July 11		July 11	Do.
84	do	39	55	50	N.	do	1902	35	Apr. 25	Apr. 30	Apr. 16	Apr. 20	Aug. 1	July 10	Oct. 10	July 20	

84	....do	39	55	50	N.	....do	1903	30	Apr. 18	Apr. 25	May 2	Apr. 1	July 25	July 15	Oct. -	July 15	
84	....do	39	55	50	N.	....do	1904	37	May 3	May 8		Apr. 25	..do	July 1		July 1	
80	....do	40	5	50	N.	Gravelly loam	1904	40	May 5	..do	Apr. 24		June 1	July 20	Oct. 10	July 4	
97	....do	40	5	60	SW.	Sandy loam	1905	35	Apr. 14							July 20	
94	....do	40	20	150	S.	....do	1902	38	Apr. 23	Apr. 27	Apr. 28	Apr. 20	June 27	July 8		July 8	July.
94	....do	40	20	150	S.	....do	1905	41	Apr. 29	May 4	Apr. 19	Apr. 10		July 10	Oct. -	July 10	Do.
94	....do	40	20	150	S.	....do	1906	42	Apr. 30	May 5		Apr. 18	June 5	..do	Oct. 14	..do	Do.
94	....do	40	20	150	S.	....do	1907	43	May 10	May 13		Apr. 24	July 5	July 15	Oct. 20	July 20	Do.
98	....do	40	30	600	S.	Red shale	1905	14	May 1	May 6					Oct. -		
88	....do	40	50	500	E.	Sandy loam	1907	18	May 8	May 12	Apr. 25	Apr. 14		July 25	Oct. 10	July 25	July.
101	....do	41	10	550	SE.	Gravelly	1904	15	May 6	May 17	Apr. 23	Apr. 28			Sept. 22		
103	....do	41	15	400	SW.	Sandy loam	1904		May 10	May 15	May 5				Sept. 28		

EARLY RIPE.

6	North Carolina	35	5	200	None.	Sandy	1904		Mar. 18	Mar. 24							
3	....do	35	25	770	N.	....do	1905	8	Apr. 2	Apr. 9	Apr. 18	Mar. 20	May 22	June 10	Oct. 22	June 10	
13	....do	35	25	2,180	NE.	Porous clay	1904	15	Apr. 22	May 10	Apr. 17	Apr. 25	May 30	June 25	Oct. 15	June 25	
38	Virginia	37	15	2,170	NW.	Limestone clay	1902	13	Apr. 20	Apr. 29	Apr. 18	Apr. 5			Sept. 14		
38	....do	37	15	2,170	NW.	....do	1903	14	Apr. 8	Apr. 20	Apr. 5	Mar. 25			..do		
38	....do	37	15	2,170	NW.	....do	1904	15	May 1	May 7	May 16	Apr. 19	June 20		Oct. 15		
35	....do	38	30	400	NE.	Red clay	1902	15	Apr. 21	Apr. 25	Apr. 15	Mar. 29	Aug. 25	July 9	Sept. 22	June 29	July.
35	....do	38	30	400	NE.	....do	1903	16	Mar. 30	Apr. 5	Apr. 5	Mar. 20	Aug. 3	July 7	Sept. 18	June 15	Do.
35	....do	38	30	400	NE.	....do	1904	17	Apr. 24	May 1	Apr. 23	Apr. 2	July 15	July 25	Sept. 23	June 28	Do.
35	....do	38	30	400	NE.	....do	1905	18	Apr. 11	Apr. 17	Apr. 20	Mar. 31	July 12	July 12	Oct. 13	June 19	Do.
35	....do	38	30	400	NE.	....do	1906	19	Apr. 18	Apr. 22	May 10	Apr. 8	July 18	July 14	Oct. 12	July 4	Do.
76	Delaware	39	5	40	NE.	Sandy	1903	10	Apr. 4	Apr. 8	Apr. 6	Mar. 28	June 1	June 18			
76	....do	39	5	40	NE.	....do	1904	11	Apr. 27	Apr. 30	Apr. 21	Apr. 20	..do	July 1	Oct. 28		
76	....do	39	5	40	NE.	....do	1905	12	Apr. 18	Apr. 21	Apr. 19	Mar. 30	June 2	June 30	Oct. 22		
65	Maryland	39	20	75		Gravelly loam	1902	7	Apr. 23	Apr. 27		Apr. 1		July 5	Nov. -		
65	....do	39	20	75		....do	1903	8	Apr. 9	Apr. 20		..do					
94	New Jersey	40	20	150	S.	Sandy loam	1903	30	Apr. 22	Apr. 27	May 5	Apr. 9	June 13	July 11	Oct. -		July.

FALL PIPPIN.

10[a]	North Carolina	35	30	4,000	NE.	Clay loam	1902	6	May 2	May 6	Apr. 25	May 8	July 26	Oct. 15	Oct. 3	Nov. 1	Dec.
33	Virginia	37	0	5	None.	Sandy loam	1904	8	Apr. 23	Apr. 28	Apr. 20	Apr. 3	June 23	Sept. 1	Oct. 17		
38	....do	37	15	2,170	NW.	Limestone clay	1903	12	Apr. 15	..do	Apr. 5	Apr. 28		Sept. 14			
38	....do	37	15	2,170	NW.	....do	1904	13	May 6	May 11	May 16	Apr. 22	June 29	Oct. 15			
72	Delaware	39	10	70	None.	Sandy loam	1902	10	Apr. 22	Apr. 25				Sept. 15	Oct. 20	Sept. 15	Dec.
87	New Jersey	39	15	40	SW.	....do	1902	10	Apr. 30	May 7		Apr. 24					
93	....do	40	15	200	SE.	....do	1907	43	May 8	May 11	May 30	May 1		Sept. 6	Nov. -	Oct. -	Nov.
100	....do	40	35	600	N.	Clay loam	1903	24	Apr. 24			Apr. 1					
100	....do	40	35	600	N.	....do	1904	25	May 10	May 16	Apr. 22	May 3					
103	....do	41	15	400	SW.	Sandy loam	1904		May -	May 14	May 5				Sept. 28		

[a] Frost killed the entire crop.

[b] Frost seriously injured crop.

TABLE IV.—*Phenological records—Apples*—Continued.

FAMEUSE.

Observer's number.	State.	Approximate latitude.	Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
		° ′														
38	Virginia	37 15	2,170	NW.	Limestone clay	1902	13	Apr. 25	May 2	Apr. 18	Apr. 11			Sept. 14		
38	do	37 15	2,170	NW.	do	1903	14	Apr. 15	Apr. 21	Apr. 15	Apr. 6		Sept. 20	do		
38	do	37 15	2,170	NW.	do	1904	15	May 6	May 10	May 16	Apr. 17	June 25		Oct. 15		
72	Delaware	39 10	70	None.	Sandy loam	1902	30	Apr. 25	Apr. 28				Aug. 15	Oct. 20		
60	Maryland	39 35	75	SW.	Heavy loam	1902	25	Apr. 30	May 2	May 28	Apr. 23	July 5		Nov. 15		
60	do	39 35	75	SW.	do	1903	26	Apr. 28	do	Apr. 20	Apr. 2			Nov. -		
60	do	39 35	75	SW.	do	1904	27	May 4	May 9	May 11	May 1	June 30	Oct. 5	Sept. 11		
94	New Jersey	40 20	150	S.	Sandy loam	1902	38			Apr. 28	Apr. 20		Sept. 20	Oct. 10	Sept. 20	Oct.
94	do	40 20	150	S.	do	1904	40	May 8	May 11		Apr. 30	July 16	Sept. 1	Sept. 20	Sept. 10	Do.
94	do	40 20	150	S.	do	1905	41	Apr. 30	May 5	Apr. 19			do	Oct. -	Sept. 1	Do.
94	do	40 20	150	S.	do	1906	42	May 3	May 9	May 11	Apr. 18	June 5		Oct. 14		
94	do	40 20	150	S.	do	1907	43	May 10	May 13		Apr. 26	July 3	Sept. 17	Oct. 20	Oct. 1	Oct.
103	do	41 15	400	SW.	do	1904			May 14	May 5				Sept. 28		

FANNY.

Observer's number.	State.	Approximate latitude.	Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
38	Virginia	37 15	2,170	NW.	Limestone clay	1903	14	Apr. 14	Apr. 26	Apr. 5	Apr. 5		Sept. 15	Sept. 14	Oct. -	
38	do	37 15	2,170	NW.	do	1904	15			May 16	Apr. 18	June 17		Oct. 15		
72	Delaware	39 10	70	None.	Sandy loam	1902	10	Apr. 23	Apr. 26				Aug. 1	Oct. 20		

GANO.

Observer's number.	State.	Approximate latitude.	Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
38	Virginia	37 15	2,170	NW.	Limestone clay	1902	13	Apr. 26	May 2	Apr. 18	Apr. 12		Sept. 25	Sept. 14		
38	do	37 15	2,170	NW.	do	1903	14	Apr. 12	Apr. 27	Apr. 5	Apr. 7		Oct. 1	do		Mar.
38	do	37 15	2,170	NW.	do	1904	15	May 7	May 12	May 16	Apr. 20	June 24		Oct. 15		
53	do	38 25	1,400	W.	Gravelly	1902	4	Apr. 25	May 1		Apr. 10		Oct. 1		Nov. -	Feb.
53	do	38 25	1,400	W.	do	1903	5	Apr. 12	Apr. 22		Apr. 9		Oct. -		do	Do.
53	do	38 25	1,400	W.	do	1905	7	Apr. 15	Apr. 25	Apr. 24	Apr. 6		do	Oct. -		Do.
53	do	38 25	1,400	W.	do	1906	8	Apr. 25	May 1	May 11	Apr. 15		Sept. -	Oct. 8	Sept. -	Jan.

GRAVENSTEIN.

33	Virginia	37	0	5	None.	Sandy loam	1904	8	Apr. 13	Apr. 26	Apr. 20	Apr. 1	June 26	Aug. 1	Oct. 17	Aug. 1	Aug.
38	do	37	15	2,170	NW.	Limestone clay	1903	14	do	Apr. 28	Apr. 5	Mar. 25			Sept. 14		
38	do	37	15	2,170	NW.	do	1904	15	May 2	May 8	May 16	Apr. 20	June 26		Oct. 15		
35	do	38	30	400	NE.	Red clay	1902	15	Apr. 25	Apr. 26	Apr. 15	Apr. 13	Aug. 27		Oct. 22		
35	do	38	30	400	NE.	do	1903	16			Apr. 5				Oct. 18		
35	do	38	30	400	NE.	do	1904	17	Apr. 29	May 4	Apr. 23	Apr. 10	July 14		Sept. 23		
35	do	38	30	400	NE.	do	1905	5			Apr. 20	Apr. 2	July 22		Oct. 13		
54	do	39	0	1,000	NE.	Porous loam	1902	8	Apr. 23	Apr. 26	Apr. 14	Apr. 15	June 10	Sept. 1		Sept. 15	Oct.
72	Delaware	39	10	70	None.	Sandy loam	1902	10	do	do				Aug. 1	Oct. 20	Aug. 5	Aug.
84	New Jersey	39	55	50	N.	Heavy loam	1902	25	Apr. 22	Apr. 29	Apr. 16	Apr. 10	Aug. 15	July 25	Oct. 10	Aug. 1	Do.
84	do	39	55	50	N.	do	1903	26	Apr. 18	Apr. 26	May 2	Apr. 1	Aug. 1	Aug. 25	Oct. -	July 25	Sept.
84	do	39	55	50	N.	do	1904	27	May 5	May 9		Apr. 25	July 25	Aug. 1		Aug. 10	Aug.
86	do	40	0	50	NW.	Loam	1904	20	May 3	May 5		do	July 10	do			
86	do	40	0	50	NW.	do	1905	21	May 1	May 6		May 8	July 1	do	Sept. 22	Aug. -	Sept.
80	do	40	5	50	N.	Gravelly loam	1904	35	May 4	May 7	Apr. 24		June 1	Aug. 25	Oct. 10	Aug. 10	Do.
80	do	40	5	50	N.	do	1905	50	Apr. 24	May 2	Apr. 19	Apr. 18	June 7	Sept. 1	Oct. 15	Aug. 20	Nov.
80	do	40	5	50	N.	do	1906	37	Apr. 23	Apr. 28	Apr. 6		do	Aug. 25		Aug. 5	Sept.
80	do	40	5	50	N.	do	1907	50	Apr. 28	May 6	Apr. 20	Apr. 6	June 20	do			
96	do	40	15	90	N. & S.	Clay loam	1904	25	May 7	May 12		May 4		Aug. 1	Sept. 17	Aug. 10	
96	do	40	15	90	N. & S.	do	1905	26	Apr. 29	May 4	Apr. -	Apr. 15		Aug. 15	Oct. 18	Aug. 15	
96	do	40	15	90	N. & S.	do	1906	27	Apr. 30	May 2	Apr. 18	Apr. 20		July 23	do	July -	Sept.
92	do	40	15	200	SE.	do	1906	35	Apr. 23	Apr. 29	May 10				Oct. -	Aug. -	
92	do	40	15	200	SE.	do	1907	36	May 5	May 11	May 22	Apr. 29	June 20	Sept. 1	do	Sept. -	
94	do	40	20	150	S.	Sandy loam	1903	37	Apr. 25	Apr. 30	May 5	Apr. 9	June 13	Aug. 18	do	Aug. -	Aug.
100	do	40	35	600	N.	Clay loam	1903	16	Apr. 26	Apr. 28							
100	do	40	35	600	N.	do	1904	17	May 8	May 14	Apr. 22	May 1					

GRIMES. Synonym: *Grimes Golden.*

12	North Carolina	35	25	2,128	W.	Porous loam	1902	20	Apr. 24	May 1	Apr. 5	Apr. 22	July 8	Sept. 20	Oct. 15	Oct. 1	Jan.
39	Virginia	37	10	2,000	NW.	Dark loam	1902	10	Apr. 26	do	May 18	Apr. 20		Oct. 10	Sept. 10		Dec.
38	do	37	15	2,170	NW.	Limestone clay	1902	13	Apr. 27	May 4	Apr. 18	Apr. 12		Sept. 15	Sept. 14		
38	do	37	15	2,170	NW.	do	1903	14	Apr. 13	Apr. 26	Apr. 5	Apr. 6			do	Sept. 20	Oct.
38	do	37	15	2,170	NW.	do	1904	15	May 7	May 12	May 16	Apr. 20	June 24		Oct. 15		
31	do	37	25	1,400	NW.	Gravelly loam	1902	12	Apr. 20	Apr. 23	Apr. 8	Apr. 21	July -	Sept. 15		Sept. 15	Dec.
53	do	38	25	1,400	W.	do	1903	11	Apr. 11	Apr. 21		Apr. 9		Sept. -		Nov. -	Do.
53	do	38	25	1,400	W.	do	1905	19	Apr. 18	Apr. 28	Apr. 24	Apr. 6		do	Oct. -	Oct. -	Do.
53	do	38	25	1,400	W.	do	1906	20	Apr. 25	May 1	May 11	Apr. 15		Sept. 25		do	Do.
48	do	38	45	375	SE.	Porous loam	1903	10	Apr. 8	Apr. 11	Apr. 5	Apr. 16	July 1	Sept. 1	Oct. 25		Do.
48	do	38	45	375	SE.	do	1906	15	Apr. 27	Apr. 29	May 11	May 1			Oct. 11	Aug. 15	Oct.
48	do	38	45	375	SE.	do	1907	16	Apr. 29	May 1	Apr. 29			Sept. 20	Oct. 13		Dec.
54	do	39	0	1,000	NE.	do	1902	9	Apr. 24	Apr. 29	Apr. 14	Apr. 15	June 15	Sept. 10		Sept. 15	Do.
54	do	39	0	1,000	NE.	do	1903	10	Apr. 6	Apr. 20	Apr. 5	Mar. 31	June 10	do		Sept. 20	Do.
54	do	39	0	1,000	NE.	do	1904	16	May 4	May 8	Apr. 20	Apr. 25	do				
54	do	39	0	1,000	NE.	do	1905	17	Apr. 19	Apr. 26	Apr. 19	Apr. 7	do	Sept. 25			

TABLE IV.—*Phenological records—Apples*—Continued.

GRIMES—Continued.

Observer's number.	State.	Approximate latitude.	Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
		° ′														
54	Virginia	39 0	1,000	NE.	Porous loam	1906	10	Apr. 23	Apr. 28	May 8	Apr. 19	June 10	Sept. 15		Oct. 1	Mar.
54	do.	39 0	1,000	NE.	do.	1907	19	Apr. 20	Apr. 25	Apr. 23	Mar. 31	do.	do.		do.	Jan.
72	Delaware	39 10	70	None.	Sandy loam	1902	10	Apr. 22	Apr. 26				Sept. 5	Oct. 20	Sept. 15	Dec.
37	Virginia	39 10	600	NW.	Clay loam	1903		Apr. 16	Apr. 21							
68	Maryland	39 10	550	S.	do.	1906	9	Apr. 20	May 1	May 10	Apr. 17		Sept. 15	Oct. 12		
64	do.	39 25	225	SE.	Stony loam	1905	20	Apr. 28		Apr. 19	Apr. 25	Aug. 20	Sept. 1	Oct. 19	Aug. 15	Nov.
64	do.	39 25	225	SE.	do.	1906	15	Apr. 29	May 3	May 10	May 2	do.		Oct. 11		
64	do.	39 25	225	SE.	do.	1907	25	Apr. 28	May 6	May 5	Apr. 28			Oct. 17		
82	New Jersey	39 55	50	W.	Sandy loam	1902	6	Apr. 25	May 2				Sept. 1		Sept. 1	Oct.
84	do.	39 55	50	N.	Heavy loam	1902	10	Apr. 27	May 1	Apr. 16	Apr. 20	Sept. 10	Sept. 25	Oct. 10	Oct. 1	Do.

JERSEY SWEET.

Observer's number.	State.	Approximate latitude.	Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
33	Virginia	37 0	5	SW.	Sandy loam	1904	8	Apr. 18	Apr. 29	Apr. 20	Apr. 1	June 26	Aug. 4	Oct. 17	Aug. 4	Aug. 10.
38	do.	37 15	2,170	NW.	Limestone clay	1902	13	Apr. 28	May 2	Apr. 8	Apr. 10			Sept. 14		
38	do.	37 15	2,170	NW.	do.	1903	14	Apr. 14	Apr. 26	Apr. 5	Mar. 29			do.		
38	do.	37 15	2,170	NW.	do.	1904	15	May 1	May 12	May 16	Apr. 17	June 26		Oct. 15		
94	New Jersey	40 20	140	SW.	Sandy loam	1905	41	Apr. 30	May 5	Apr. 19			Aug. 10		Aug. 10	Aug.

JONATHAN.

Observer's number.	State.	Approximate latitude.	Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
47	Virginia	36 45	1,700	SE.	Porous loam	1905		Apr. 15	May 1	May 1			Sept. 15		Oct. 1	Dec.
72	Delaware	39 10	70	None.	Sandy loam	1902	7	Apr. 25	Apr. 28				do.	Oct. 20	Sept. 15	Do.
82	New Jersey	39 55	50	W.	do.	1902	6	Apr. 24	Apr. 29				Sept. 25		Sept. 20	Do.
82	do.	39 55	50	W.	do.	1903	7	Apr. 16								
99	do.	40 35	40	NW.	do.	1907	10	May 9	May 13	May 12	May 1	Sept. 15	Oct. 15		Oct. -	Apr.

									JULY.								
76	Delaware	39	5	40	None.	Sandy	1903	8	Apr. 11	Apr. 16	Apr. 6	Apr. 1	June 1	July 8			July.
76	do	39	5	40	None.	do	1905	10	Apr. 20	Apr. 24	Apr. 19	do	June 7	July 12	Oct. 22		
72	do	39	10	70	None.	Sandy loam	1902	10	Apr. 24	Apr. 27				July 10	Oct. 20		
65	Maryland	39	20	75		Gravelly loam	1902	5	Apr. 25	Apr. 29		Apr. 12					
65	do	39	20	75		do	1903	6	Apr. 18			Apr. 2					
									LIMBERTWIG.								
11	North Carolina	35	25	1,990	SE.	Porous loam	1904	20	Apr. 30	May 5	Apr. 21	May 8		Oct. 20	Oct. 24	Dec. -	Mar.
10b	do	35	30	3,500	SE.	Gravelly clay	1902	12	Apr. 29	May 7	Apr. 20	May 10	July 28	Oct. 10	Oct. 3	do	Jan.
10c	do	35	30	4,000	NE.	Clay loam	1902	8	May 1	May 9	Apr. 25	May 8	do	Oct. 20	do	do	Mar.
10d	do	35	30	4,500	SE.	Black loam	1902	12	do	May 6	Apr. 22		July 30	do	Oct. 1	do	Feb.
1	do	35	35	2,300	S.	Loam	1904	12	Apr. 15	Apr. 28	Apr. 20	Apr. 3					
1	do	35	35	2,300	S.	do	1905	13	Apr. 5	Apr. 15	Apr. 16	Mar. 27		Oct. 15	Oct. 15	Jan. -	
1	do	35	35	2,300	S.	do	1906	9	Apr. 20	Apr. 26	Apr. 18	Apr. 15			do		
5	do	35	50	1,500	N.	Black loam	1905	15	Apr. 10	Apr. 18	Mar. 30	Apr. 2	May 5	Nov. 1	Oct. -	Oct. -	May.
5	do	35	50	1,500	N.	do	1906	18	Mar. 30	Apr. 9				do		do	Mar.
4	do	35	50	1,200	S.	Sandy loam	1904	20	Apr. 15	May 1		May 15		do		do	Apr.
16	do	36	10	3,250	S.	Clay loam	1904	16	May 10	May 20	Apr. 21	Apr. 23	July 6	Oct. 15	Oct. 15	Jan. -	May.
16	do	36	10	3,250	S.	do	1905	17	Apr. 25	May 4	May 16	Apr. 16	July 11	do	Oct. 20	do	Do.
47	Virginia	36	45	1,700	SE.	Porous loam	1905		Apr. 20	May 5	May 1			Oct. 25		do	June.
38	do	37	15	2,170	NW.	Limestone clay	1902	13	Apr. 28	May 4	Apr. 18	Apr. 11		Sept. 25	Sept. 14		
38	do	37	15	2,170	NW.	do	1903	14	Apr. 17	Apr. 29	Apr. 5	Mar. 30		Oct. 1	do		
38	do	37	15	2,170	NW.	do	1904	15	May 6	May 11	May 16	Apr. 24	June 30		Oct. 15		
44	do	37	45	630	SW.	Loam	1904	15	Apr. 24		Apr. - [a]	Apr. 6	do				
50	do	37	55	200	E.&W.	Sandy loam	1903	16	Mar. 29	Apr. 4		Apr. 5		Oct. -		Oct. -	Mar.
19	do	38	5	900	S.	Red clay	1905	18	Apr. 11	Apr. 15	Apr. 19	Apr. 1		Oct. 25	Oct. 7	Mar. -	May.
									LONDON SWEET.								
35	Virginia	38	30	400	NE.	Red clay	1902	15	Apr. 24	Apr. 26	Apr. 15	Apr. 16	Aug. 27		Oct. 22		
35	do	38	30	400	NE.	do	1903	16	Apr. 7	Apr. 14	Apr. 5	Mar. 20	Aug. 2	Aug. 22	Oct. 18	Aug. -	Oct.
35	do	38	30	400	NE.	do	1904	17	Apr. 30	May 5	Apr. 23	Apr. 8	Aug. 22	Sept. 1	Sept. 23	do	Do.
35	do	38	30	400	NE.	do	1905	18	Apr. 14	Apr. 22	Apr. 20	Mar. 30	July 16	do	Oct. 13	do	Sept.

[a] Frost seriously injured crop.

TABLE IV.—*Phenological records—Apples*—Continued.

MAIDEN BLUSH.

Observer's number.	State.	Approximate latitude.	Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
		° ′														
38	Virginia	37 15	2,170	NW.	Limestone clay	1902	13	Apr. 27	May 3	Apr. 18	Apr. 10			Sept. 14		
38	do	37 15	2,170	NW.	do	1903	14	Apr. 15	Apr. 27	Apr. 15	Apr. 6			do.		
38	do	37 15	2,170	NW.	do	1904	15	May 8	May 13	May 16	Apr. 22	June 27		Oct. 15		
31	do	37 25	1,400	NW.	Gravelly loam	1902	12	Apr. 20	Apr. 24	Apr. 8	Apr. 20	July -	Sept. 25		Sept. 1	Dec.
35	do	38 30	400	NE.	Red clay	1902	15	Apr. 24	Apr. 26	Apr. 15	Apr. 13	Aug. 25	Aug. 1	Oct. 22	July 25	Aug.
35	do	38 30	400	NE.	do	1903	16	Apr. 7	Apr. 12	Apr. 5	Mar. 20	July 28	Aug. 15	Oct. 18	July 1	Sept.
35	do	38 30	400	NE.	do	1904	17	May 2	May 5	Apr. 23	Apr. 9	July 17		Sept. 23		
35	do	38 30	400	NE.	do	1905	18	Apr. 16	Apr. 24	Apr. 20	Mar. 30	July 14	Aug. 1	Oct. 13	July 10	Sept.
54	do	39 10	1,000	NE.	Porous loam	1903	20	Apr. 9	Apr. 20	Apr. 5	Mar. 28	June 10	do.			Aug.
54	do	39 10	1,000	NE.	do	1905	17	Apr. 20	Apr. 25	Apr. 19	Apr. 6	do.				
54	do	39 10	1,000	NE.	do	1907	19	do.	do.	Apr. 23	Mar. 31	June 15	Aug. 15		Aug. 15	Sept.
55	do	39 10	600	E.	Sandy loam	1907	14	Apr. 24	Apr. 30	May 9	Mar. 27		do.		Aug. 25	Do.
72	Delaware	39 10	70	None.	do	1903	30	Apr. 22	Apr. 26				Aug. 1	Oct. 20	Aug. 5	Do.
89	New Jersey	39 40	150	None.	Porous loam	1904	25	May 5	May 10	Apr. 17	May 2	June 15	Aug. 5	Sept. 25	do.	
82	do	39 55	50	W.	Sandy loam	1902	20	Apr. 24	Apr. 28				Aug. 15		Aug. 15	Sept.
94	do	40 20	150	S.	do	1902	38	Apr. 27	May 4	Apr. 28	Apr. 20	June 27	Aug. 10	Oct. 10	Aug. -	Do.
94	do	40 20	150	S.	do	1903	39	Apr. 28	May 2	May 5	Apr. 9	June 13	Aug. 18	Oct. -	do.	Aug.
94	do	40 20	150	S.	do	1904	40	May 7	May 11		Apr. 30	July 16	Aug. 25	Sept. 20	Sept. 1	Sept.

MILAM.

Observer's number.	State.	Approximate latitude.	Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
53	Virginia	38 25	1,400	W.	Gravelly loam	1903	9	Apr. 12	Apr. 24		Apr. 9		Sept. -		Nov. -	Feb.
53	do	38 25	1,400	W.	do	1905	11	Apr. 17	Apr. 25	Apr. 24	Apr. 11		do		Sept. -	Jan.
53	do	38 25	1,400	W.	do	1906	12	Apr. 27	May 2	May 11	Apr. 13		do.			
54	do	39 0	1,000	NE.	Porous loam	1902	15	Apr. 24	Apr. 29	May 14	Apr. 17	June 15	Sept. 10		Sept. 15	Nov.
54	do	39 0	1,000	NE.	do	1903	16	Apr. 13	Apr. 22	May 5	Apr. 1	June 10	Sept. 25		Oct. 1	Dec.
54	do	39 0	1,000	NE.	do	1904	17	May 5	May 10	May 20	Apr. 22	do.				
54	do	39 0	1,000	NE.	do	1905	18	Apr. 22	Apr. 25	May 19	Apr. 10	do.				

NERO.

38	Virginia	37	15	2,170	NW.	Limestone clay	1902	13	Apr. 26	May 3	Apr. 18	Apr. 10			Sept. 14		
38	....do	37	15	2,170	NW.	....do	1903	14	Apr. 15	Apr. 20	Apr. 5	Apr. 13		Sept. 25	..do.		
38	....do	37	15	2,170	NW.	....do	1904	15	May 3	May 8	May 16	Apr. 16	June 26		Oct. 15		
76	Delaware	39	5	40	NE.	Sandy loam	1903	19	Apr. 8	Apr. 20	Apr. 6	Mar. 28	June 16	Oct. 5			Jan.
76	....do	39	5	40	NE.	....do	1904	20	Apr. 27	May 4	Apr. 21	Apr. 23	June 14	Oct. 18	Oct. 28		Feb.
76	....do	39	5	40	NE.	....do	1905	21	Apr. 19	Apr. 25	Apr. 19	Mar. 28	May 30	Oct. 19	Oct. 22	Nov. 1	Do.
82	New Jersey	39	55	50	W.	....do	1902	6	Apr. 24	Apr. 28				Oct. 1		Oct. 1	Dec.
82	....do	39	55	50	W.	....do	1903	7	Apr. 16								
93	....do	40	15	200	SE.	....do	1907	20	May 8	May 11	May 30	May 1		Nov. 1	Nov. -	Dec. -	Mar.
94	....do	40	20	150	S.	....do	1902	38	Apr. 22	Apr. 23	Apr. 28	Apr. 20	June 27	Oct. 10	Oct. 10	Nov -	Dec.
94	....do	40	20	150	S.	....do	1903	39	Apr. 20	Apr. 26	May -	Apr. 9	June 13	Oct. 1	Oct. -	...do...	Feb.
94	....do	40	20	150	S.	....do	1905	41	Apr. 27	May 1	Apr. 19			Oct. -	...do...	Oct. -	Nov.

NORTHERN SPY.

4	North Carolina	35	50	1,200	S.	Sandy loam	1904	20	Apr. 15	May 1		May 15					
38	Virginia	37	15	2,170	NW.	Limestone clay	1902	13	Apr. 30	May 5	Apr. 18	Apr. 11			Sept. 14		
38	....do	37	15	2,170	NW.	....do	1903	14	...do...	May 12	Apr. 5	Apr. 16		Sept. 20	..do...	Oct. 1	Dec.
38	....do	37	15	2,170	NW.	....do	1904	15	May 9	May 14	May 16	Apr. 28	June 24		Oct. 15		
29	....do	37	20	1,200	SE.	Red clay	1903	20	Apr. 10	Apr. 18	Apr. 6	Apr. 20		Aug. -		Sept. -	Dec.
28	....do	37	20	1,000	None.	Sandy loam	1904	15	Apr. 15	Apr. 25	May 7			Oct. 20		Oct. -	Late.
28	....do	37	20	1,000	None.	....do	1905	10	Apr. 9	Apr. 16	Mar. 28	Apr. 1	June 10		Oct. 13		
28	....dc	37	20	1,000	None.	....do	1906	20	Apr. 12	Apr. 19	Mar. 29	Apr. 2			Nov. 20		
54	....do	39	0	1,000	NE.	Porous loam	1902	8	Apr. 26	Apr. 30	Apr. 14	Apr. 22	June 15	Sept. 20		Oct. 1	
54	....do	39	0	1,000	NE.	....do	1903	9	Apr. 18	Apr. 27	Apr. 5	Apr. 6	June 10	Sept. 25		...do...	
54	....do	39	0	1,000	NE.	....do	1904	10	May 6	May 11	Apr. 20	May 2	...do...				Dec.
54	....do	39	0	1,000	NE.	....do	1905	11	Apr. 24	Apr. 29	Apr. 19	Apr. 11	...do...	Sept. 20			
54	....do	39	0	1,000	NE.	....do	1906	18	Apr. 28	May 2	May 8	Apr. 20	...do...	Oct. 1		Oct. 1	Mar.
54	....do	39	0	1,000	NE.	....do	1907	19	Apr. 29	May 4	Apr. 23	Apr. 4	June 15	...do...		Dec. -	Do.
73	Delaware	39	10	100		Sandy loam	1902	20	Apr. 28	...do...		Apr. 10		...do...		Oct. 15	Dec.
60	Maryland	39	35	75	SSW.	Heavy loam	1902	25	May 1	...do...	May 28	Apr. 28	July 12	Sept. 16	Nov. 15	Aug. 12	Feb.
60	....do	39	35	75	SSW.	....do	1903	26	Apr. 28	May 2	Apr. 20	Apr. 6			Nov. -		
60a	....do	39	35	125	SSW.	Sandy loam	1902	35	Apr. 29	...do...	...do...	Apr. 25	July 10	Sept. 16	Nov. 15	Aug. 10	Feb.
60a	....do	39	35	125	SSW.	....do	1903	36	Apr. 20	Apr. 26	...do...	Apr. 4		Sept. 20	Nov. -		
60a	....do	39	35	125	SSW.	....do	1904	37	May 4	May 13	Apr. 21	May 1	July 3	Oct. 3	Sept. 17		
96	New Jersey	40	15	90	N. & S.	Clay loam	1903	19	Apr. 25			May 7					
96	....do	40	15	90	N. & S.	....do	1904	20	May 8	May 18	Apr. 22	May 5					
92	....do	40	15	200	SE.	....do	1906	35	Apr. 26	May 3	May 10			Oct. 15	Oct. -	Oct. 15	Jan.
92	....do	40	15	200	SE.	....do	1907	36	May 11	May 15	May 22	May 5	June 10	Oct. 1	...do...	Dec. 25	Do.
94	....do	40	20	150	S.	Sandy loam	1904	40				May 1	July 16	Aug. -		Aug. 10	Sept.
94	....do	40	20	150	S.	....do	1905	41	May 4	May 7	Apr. 19			Sept. -	Oct -	Sept. -	Oct.
94	....do	40	20	150	S.	....do	1906	42	May 5	May 10	May -	Apr. 22	June 5	Sept. -	...do...	..do...	
94	....do	40	20	150	S.	....do	1907	43	May 16	May 20		May 23	July 4	Sept. 20	Oct. 20	Oct. -	Oct.
98	....do	40	30	600	S.	Red shale	1905	14	May 3	May 12	Apr. 16	May 6			Oct. -		
104	....do	41	0	600	None.	Clay loam	1904	12	May 13		Apr. 23	May 8	July 6	Oct. 18	Sept. 22	Nov. -	Jan.
104	....do	41	0	600	None.	....do	1905	14	May 8	May 17	Apr. 24	May 28	July 8	Oct. 10	Oct. 22	...do...	Mar.

Observer's number.	State.	Approximate latitude.	Elevation (feet).	Slope	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
		° ′														
104	New Jersey	41 0	600	None.	Clay loam	1906	15	May 12	do.	May 11	Apr. 30	July 2	Oct. 12	Oct. 12	Nov. -	Jan.
104	do	41 0	600	None.	do	1907	16	May 17	May 22	May 12	May 1	July 5	Oct. 24	Oct. 25	do	Mar.
102	do	41 10	800	None.	Sandy loam	1904	23	May 13	May 19							
102	do	41 10	800	None.	do	1905	24	May 9		Apr. 26					Dec. -	Apr.
103	do	41 15	400	SW.	do	1904		May 12	May 16	May 5				Sept. 28		
						OLDENBURG.										
33	Virginia	37 0	5	None.	Sandy loam	1903	7			Apr. 5	Mar. 24		July 22	Oct. 27	July 25	July 30.
33	do	37 0	5	None.	do	1904	8	Apr. 12	Apr. 24	Apr. 20	Apr. 1	June 23	July 18	Oct. 17	July 20	July 28.
38	do	37 15	2,170	NW.	Limestone clay	1902	13	Apr. 26	May 2	Apr. 18	Apr. 11			Sept. 14		
38	do	37 15	2,170	NW.	do	1903	14	Apr. 20	Apr. 28	Apr. 5	Mar. 27			do		
38	do	37 15	2,170	NW.	do	1905	15	Apr. 29	May 7	May 16	Apr. 21	June 22		Oct. 15		
31	do	37 25	1,400	NW.	Gravelly loam	1902	12	Apr. 21	Apr. 24	Apr. 8	do	July -	July 1		July 1	Aug. -.
35	do	38 30	400	NE.	Red clay	1902	3			Apr. 15	Apr. 12	Aug. 26		Oct. 22		
35	do	38 30	400	NE.	do	1903	4	Apr. 8	Apr. 13	Apr. 5	Mar. 29	Aug. 3		Oct. 18		
35	do	38 30	400	NE.	do	1904	5	Apr. 29	May 5	Apr. 23	Apr. 10	July 17	Aug. 1	Sept. 23	July 25	Aug. 15.
35	do	38 30	400	NE.	do	1905	6	Apr. 17	Apr. 23	Apr. 20	Apr. 3	July 24		Oct. 13	July 7	Aug. 19.
35	do	38 30	400	NE.	do	1906	7	Apr. 19	Apr. 25	May 10	Apr. 15	July 22	Aug. 9	Oct. 11	Aug. 1	Sept. 10
48	do	38 45	375	SE.	Porous loam	1905		Apr. 21	Apr. 23	Apr. 19						
57	Maryland	39 0	75	None.	Sandy	1907		Apr. 22	May 2	Apr. 18	Mar. 25					
87	New Jersey	39 15	40	SW.	Sandy loam	1902	10	Apr. 28	May 5		Apr. 22					
63	Maryland	39 30	150	N.	Clay loam	1907	20	Apr. 29	May 8	May 12	Apr. 18	July 29	Aug. 10	Oct. 15	Aug. 1	Aug. 20.
84	New Jersey	39 55	50	N.	Heavy loam	1902	25	Apr. 25	Apr. 30	Apr. 16	Apr. 20	Aug. 1	July 25	Oct. 10	July 25	Aug. 10.
84	do	39 55	50	N.	do	1903	26	Apr. 18	Apr. 27	May 2	Apr. 5	July 25	July 30	Oct. -	July 30	Do.
84	do	39 55	50	N.	do	1904	27	May 1	May 6		Apr. 27	July 10	July 15		July 25	Aug. 1.
86	do	40 0	50	NW.	Loam	1904	20	do	May 5		Apr. 25	do	July 10	Sept. 22	July 10	Do.
86	do	40 0	50	NW.	do	1905	21	Apr. 27	May 2		Apr. 1	July 1		Nov. -	July 15	Do.
81	do	40 10	75	None.	Heavy loam	1907	12	May 2	May 10		Apr. 28			Oct. 21		
94	do	40 20	150	SW.	Sandy loam	1904	14	May 8	May 11		do	July 16		Sept. 20		
94	do	40 20	150	SW.	do	1905	15	May 1	May 5	Apr. 19						
104	do	41 0	350	None.	Clay loam	1904	12	May 9	May 13	Apr. 23	May 2	July 1	Sept. 8	Sept. 22	Sept. 20	Oct.
104	do	41 0	350	None.	do	1905	16	May 6	May 10	Apr. 24	Apr. 26	do	Aug. 18	Oct. 22	Aug. 18	
104	do	41 0	350	None.	do	1906	12	May 5	May 11	May 11	Apr. 20	June 26	Aug. 21	Oct. 12	Aug. 30	
104	do	41 0	350	None.	do	1907	13	May 13	May 18	May 12	Apr. 27	July 28	Aug. 19	Oct. 25	Aug. 19	
103	do	41 15	400	SW.	Sandy loam	1904		May 8	May 13	May 5				Sept. 28		

PRIMATE.

94	New Jersey	40	20	140	S.	Sandy loam	1902	38	Apr. 23	Apr. 27	Apr. 28	Apr. 20	June 27	July 8	Oct. 10	July 8	Aug. 1.
94	....do	40	20	140	S.	....do	1903	39	Apr. 20	...do...	May -	Apr. 9	June 13	...do...	Oct. -	July 1	July.
94	....do	40	20	140	S.	....do	1904	40	May 4	May 10		Apr. 20	June 16	July 14	Sept. 20	July 15	July 25.
94	....do	40	20	140	S.	....do	1905	41	Apr. 30	May 4	Apr. 19			..do...		..do...	Aug. 1.
94	....do	40	20	140	S.	....do	1906	42	...do...	May 5		Apr. 18	June 5	July 11	Oct. -	July 13	July 20.

RALLS. Synonyms: *Geniton, Rawles Genet, Neverfail.*

47	Virginia	36	45	1,700	SE.	Porous loam	1905	......	May 10	May 20	May 1					Dec. 1	Apr.
26	....do	37	15	900	N.	Sandy loam	1902	15	Apr. 26	May 8							
26	....do	37	15	900	N.	....do	1903	16	Apr. 19	Apr. 25			June 25	Oct. 10		Nov. 15	Jan.
38	....do	37	15	2,170	NW.	Limestone clay	1903	14	May 7	May 12	Apr. 5	Mar. 29			Sept. 14		
38	....do	37	15	2,170	NW.	....do	1904	15			May 16	May 6	July 15		Oct. 15		
28	....do	37	20	1,000	N.	Porous loam	1904	5	May 15	May 25	May 7			Oct. 20			
25	....do	37	20	1,000	SE.	Cecil clay	1902	15	May 1	May 10	Mar. 20	May 1	Aug. 1	Oct. 15	Oct. 20	Jan. 1	Mar.
25	....do	37	20	1,000	SE.	....do	1903	16	May 10	May 20	Apr. 20	May 10	...do...	Nov. 1	Oct. 15	Dec. 1	Feb.
25	....do	37	20	1,000	SE.	....do	1904	17	May 15	May 25	May 5	May 15	July 20	...do...	Oct. 10	...do...	Do.
25	....do	37	20	1,000	SE.	....do	1905	18	May 10	May 20	Apr. 15	May 10	...do...	...do...	Oct. 20	...do...	Mar.
27	....do	37	30	1,000	NE.	Clay loam	1902	26	May 1	May 4	Mar. -	Apr. 20		Oct. 15	Nov. -	...do...	Feb.
27	....do	37	30	1,000	NE.	....do	1904	28	...do...	May 3	Apr. 22			Sept. 15	Oct. 16	Nov. -	Do.
42	....do	37	45	800	SE.	Cecil clay	1903	15	Apr. 26	May 10	Apr. 15						
36	....do	38	15	650	......	Sandy loam	1902	18	Apr. 24	Apr. 28	May 3	Apr. 24			Oct. 17		
53	....do	38	25	1,400	W.	Gravelly loam	1905	19	May 4	May 12	Apr. 24	May 1			Oct. -		
53	....do	38	25	1,400	W.	....do	1906	20	May 6	May 14	May 11	Apr. 28		Oct. 15	Oct. 8	Dec....	Apr.
35	....do	38	30	400	NE.	Red clay	1902	2			Apr. 15	Apr. 22	Aug. 29		Oct. 22		
35	....do	38	30	400	NE.	....do	1903	3			Apr. 5	Apr. 13	Aug. 4		Oct. 18		
35	....do	38	30	400	NE.	....do	1904	4	May 7	May 9	Apr. 23	Apr. 29	July 20	Oct. 1	Sept. 23		
35	....do	38	30	400	NE.	....do	1905	5			Apr. 20	Apr. 14	July 18		Oct. 13		
48	....do	38	45	375	SE.	Porous loam	1903	15	Apr. 16	Apr. 22	Apr. 5	Apr. 24	July 8	Sept. 30	Oct. 25		Feb.
48	....do	38	45	375	SE.	....do	1905	20	Apr. 26	Apr. 28	Apr. 19	Apr. 27					
48	....do	38	45	375	SE.	....do	1906	60	Apr. 28	Apr. 30	May 11	May 4			Oct. 11	Sept....	Jan.
48	....do	38	45	375	SE.	....do	1907	......	May 8	May 11	Apr. 20			Sept. 20	Oct. 13		Do.
54	....do	39	0	1,000	NE.	....do	1902	19	Apr. 30	May 3	Apr. 14	Apr. 23	June 20	Oct. 1		Nov....	Late.
54	....do	39	0	1,000	NE.	....do	1903	20	Apr. 27	May 2	Apr. 5	Apr. 29	June 10	Oct. 26		Dec....	June.
54	....do	39	0	1,000	NE.	....do	1904	21	May 8	May 13	Apr. 20	May 2	...do...				
54	....do	39	0	1,000	NE.	....do	1905	22	Apr. 26	May 1	Apr. 19	Apr. 17	...do...				
54	....do	39	0	1,000	NE.	....do	1906	23	May 1	May 5	May 8	Apr. 23	...do...	Oct. 1		Oct....	Apr.
54	....do	39	0	1,000	NE.	....do	1907	......	Apr. 30	...do...	Apr. 23	Apr. 4	June 15	...do...		Dec....	June.
55	....do	39	0	600	E.	....do	1907	14	May 4	May 11	May 9	Apr. 15		Nov. 1	Oct. 10	...do...	Apr.
69	Maryland	39	15	50	None.	Sandy loam	1904	14	Apr. 28	May 14		Apr. 28					
94	New Jersey	40	20	150	S.	....do	1905	41	May 4	May 8	Apr. 19	Apr. 20		Oct. -	Oct. -		June.
94	....do	40	20	150	S.	....do	1907	43	May 13	May 16		May 28	July 4		Oct. 20		

TABLE IV.—*Phenological records—Apples*—Continued.

RED ASTRACHAN.

Observer's number.	State.	Approximate latitude.	Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
		° ′														
12	North Carolina	35 25	2,128	W.	Porous loam	1902	19	Apr. 18	Apr. 24	Apr. 5	Apr. 16	June 25	July 1	Oct. 15	June 22	July 10.
12	do	35 25	2,128	W.	do	1903	20	Mar. 31	Apr. 7	Apr. 6	Apr. 8					
12	do	35 25	2,128	W.	do	1904	21	Apr. 12	Apr. 20	Apr. 11	Apr. 22	July 26	July 10	Oct. 15	July 12	Aug. 1.
12	do	35 25	2,128	W.	do	1905	22	Apr. 2	Apr. 10	Apr. 7	Apr. 12	July 16	July 15	Oct. 14	July 15	July 25.
1	do	35 35	2,300	S.	Sandy loam	1902	10	Apr. 20	Apr. 26	Apr. 18	do			Oct. 15	June 15	Aug. 1.
1	do	35 35	2,300	S.	do	1904	12	Apr. 12	Apr. 28	Apr. 20	Apr. 3			do		
1	do	35 35	2,300	S.	do	1905	8	Apr. 5	Apr. 15	Apr. 16	Mar. 27			Oct. 16		
1	do	35 35	2,300	S.	do	1906	9	Apr. 20	Apr. 26	Apr. 18	Apr. 12			Oct. 15		
5	do	35 50	1,500	N.	Black loam	1905	18	Mar. 30	Apr. 15	Mar. 30	Mar. 20	May 1	July 15	Oct -	June 30	Aug. 15.
17	do	36 15	3,000	SE.	Clay loam	1904	10	Apr. 25	May 1	May 3	May 1		Aug. 5	Oct. 11	July 25	Sept. 1.
33	Virginia	37 0	5	None.	Sandy loam	1903	7	Mar. 31	Apr. 10	Apr. 5	Mar. 22		July 5	Oct. 27	July 5	July 15.
33	do	37 0	5	None.	do	1904	8	Apr. 12	Apr. 20	Apr. 20	Mar. 27	June 28	July 20	Oct. 17	July 20	July 26.
26	do	37 0	5	None.	do	1902	15	Apr. 19	Apr. 25			June 5	June 18		June 15	July 28.
26	do	37 0	5	None.	do	1903	16	Apr. 1	Apr. 8							
46	do	37 0	500	S.	do	1903	15		Apr. 2		Apr. 1					
38	do	37 0	2,170	NW.	Limestone clay	1902	13	Apr. 28	May 2	Apr. 18	Apr. 11			Sept. 14		
38	do	37 0	2,170	NW.	do	1903	14	Apr. 16	Apr. 20	Apr. 5	Mar. 30			do		
38	do	37 0	2,170	NW.	do	1904	15	May 4	May 10	May 16	Apr. 20	June 20		Oct. 15		
31	do	37 25	1,400	NW.	Gravelly loam	1902	12	Apr. 21	Apr. 24	Apr. 8	Apr. 21	July -	July 1		July 1	Aug.
50	do	37 55	200	E.&W.	Sandy loam	1902	15	Apr. 17	Apr. 23	Apr. 19	May 10		July -	Oct. 30	July -	Aug. 15.
50	do	37 55	200	E.&W.	do	1903	16	Mar. 28	Apr. 2		Apr. 5		do		July 5	Aug. 1.
50	do	37 55	200	E.&W.	do	1904	17	Apr. 20	Apr. 25	Apr. 6	Apr. 25		July 1	Sept. 7		
50	do	37 55	200	E.&W.	do	1905	18	Apr. 9	Apr. 14	Apr. 19	Apr. 14		do	Oct. 22	July 1	Aug. 1.
50	do	37 55	200	E.&W.	do	1906	19	Apr. 15	Apr. 25	May 11	Apr. 25		July 5		July 5	Do.
35	do	38 30	400	NE.	Red clay	1902	3	Apr. 25	Apr. 27	Apr. 15	Apr. 13	Aug. 23		Oct. 22		
35	do	38 30	400	NE.	do	1903	4	Apr. 1	Apr. 9	Apr. 5	Mar. 21	Aug. 1	July 15	Oct. 18		
35	do	38 30	400	NE.	do	1904	5	May 1	May 6	Apr. 23	Apr. 9	July 11		Sept. 23		
35	do	38 30	400	NE.	do	1905	6	Apr. 10	Apr. 18	Apr. 20	Mar. 31	July 13		Oct. 13		
35	do	38 30	400	NE.	do	1906	7	Apr. 19	Apr. 23	May 10	Apr. 10	July 16		Oct. 11		
61	Maryland	38 40	45	None.	Sandy loam	1907	15	Apr. 12	Apr. 29							
48	Virginia	38 45	375	SE.	Porous loam	1903	15	Apr. 5	Apr. 8	Apr. 5	Apr. 15	June 28		Oct. 25		
48	do	38 45	375	SE.	do	1905	20	Apr. 20	Apr. 24	Apr. 19	Apr. 20					
48	do	38 45	375	SE.	do	1906	33	Apr. 24	Apr. 27	May 11	Apr. 30		June 28	Oct. 11	June 24	July 11.
48	do	38 45	375	SE.	do	1907		Apr. 22	Apr. 26	Apr. 20				Oct. 13		Aug. 20.
78	Delaware	38 45	50	None.	Sandy loam	1904	21	Apr. 25	May 4	Apr. 22	Apr. 13					
75	do	39 0	60	None	do	1907	20	Apr. 20	Apr. 26	Apr. 3	Apr. 18		July 9	Oct. -	July 9	
54	Virginia	39 0	1,000	NE.	Porous loam	1902	18	Apr. 22	Apr. 24	Apr. 14	Apr. 15	June 15	June 28		June 28	July 15.

54	do.	39	0	1,000	NE.	do.	1903	19	Apr. 9	Apr. 18	Apr. 5	Mar. 25	June 10	July 1		July 4	Do.
54	do.	39	0	1,000	NE.	do.	1904	20	May 1	May 6	Apr. 20	Apr. 20	do.				
54	do.	39	0	1,000	NE.	do.	1905	21	Apr. 14	Apr. 24	Apr. 19	Apr. 5	do.				
54	do.	39	0	1,000	NE.	do.	1906	22	Apr. 20	Apr. 27	May 8	Apr. 16	do.	July 1		July 1	Aug.
54	do.	39	0	1,000	NE.	do.	1907	19	Apr. 17	Apr. 24	Apr. 23	Mar. 31	June 15	do.		do.	Aug. 15.
76	Delaware	39	5	40	None.	Sandy	1903	15	Apr. 3	Apr. 18	Apr. 6	Mar. 28	June 28	June 29			
76	do.	39	5	40	None.	do.	1904	16	Apr. 29	Apr. 30	Apr. 21	Apr. 16	June 14	July 11	Oct. 28	July 11	July 23.
76	do.	39	5	40	None.	do.	1905	17	Apr. 19	Apr. 21	Apr. 19	Mar. 30	June 2	July 4	Oct. 22		Aug.
72	do.	39	10	70	None.	Sandy loam	1902	25	Apr. 22	Apr. 26				July 5	Oct. 20	July 5	
73	do.	39	10	70	None.	do.	1902	20	Apr. 25	May 1		Apr. 10		July 10		July 10	
74	do.	39	10	70	None.	do.	1903	8	Apr. 17	Apr. 22	Apr. 6			July 20	Oct. 22	July 20	
69	Maryland	39	15	50	None.	do.	1904	14	Apr. 28	May 5		Apr. 28					
87	New Jersey	39	15	40	SW.	do.	1902	10	do.	May 4		Apr. 23				July 7	
67	Maryland	39	20	50	E.	do.	1903	25	Apr. 9	Apr. 13	Apr. 6	Apr. 6		July 10	Oct. 26	July 20	
65	do.	39	20	75		do.	1902	7	Apr. 22	Apr. 25		Mar. 27		July 14		July 14	July 28.
65	do.	39	20	75		do.	1903		Apr. 15			Apr. 1					
60	do.	39	35	75	SSW.	Heavy loam	1902	25	Apr. 28	May 2	May 28	Apr. 26	July 5	July 12	Nov. 15	July 10	
60	do.	39	35	75	SSW.	do.	1903	26	Apr. 24	Apr. 29	Apr. 20	Apr. 2			Nov. -		
60	do.	39	35	75	SSW.	do.	1904	27	May 5	May 9	May 11	Apr. 30	June 29	July 30	Sept. 17		Aug. 8.
79	New Jersey	39	35	90	NNW.	Gravelly loam	1902	50	Apr. 20	Apr. 25	Apr. 15	Apr. 16		July 12	Oct. 22	July 12	
80	do.	39	40	150	None.	do.	1904	27	May 5	May 8	Apr. 17	Apr. 30	June 15	July 15	Sept. 25	July 15	
91	do.	39	50				1906	35	Apr. 26	Apr. 28		Apr. 14	July 20	July 20		July 10	Aug. 10.
82	do.	39	55	50	W.	Sandy loam	1902	20	Apr. 20	Apr. 26				July 8		July 8	July 18.
96	do.	40	15	90	N. & S.	Clay loam	1904	37	May 7	May 12		May 5		July 13	Sept. 17	July 13	
96	do.	40	15	90	N. & S.	do.	1905	38	Apr. 30	May 4		Apr. 14		July 11	Oct. 18	July 11	
96	do.	40	15	90	N. & S.	do.	1906	39	do.	May 2	Apr. -	Apr. 20		July 10	Oct. -	July 15	
94	do.	40	20	140	SW.	Sandy loam	1905	41	Apr. 29	May 4	Apr. 19			July 10		July 10	July 30.
99	do.	40	35	40	NW.	do.	1907	12	May 9	May 12	May 12	May 1			Oct. 5		

RED JUNE.

6	North Carolina	35	5	200	None.	Sandy	1902		Apr. 8	Apr. 16		Apr. 22					
6	do.	35	5	200	None.	do.	1904		Mar. 31	Apr. 6							
11	do.	35	25	1,990	SE.	Porous loam	1904	20	Apr. 15	Apr. 20	Apr. 21	Apr. 30		July 1	Oct. 24	July 20	Aug. 10.
11	do.	35	25	1,990	SE.	do.	1906	22	Apr. 8	Apr. 16	May 10	Apr. 5			Oct. 10		
12	do.	35	25	2,130	W.	do.	1902	25	Apr. 18	Apr. 26	Apr. 5	Apr. 14	July 1	July 1	Oct. 15	June 28	Aug. 25.
10	do.	35	30	2,875	SW.	Clay loam	1903	12	Mar. 27	Apr. 10	Apr. 28	Apr. 2	July 10	July 25	Oct. 25		
2	do.	35	30	2,900	E.	do.	1904	8	Apr. 16	Apr. 28	Apr. 20	Apr. 5		July 10	Oct. 14		
2	do.	35	30	2,900	E.	do.	1905	9	Apr. 2	Apr. 13	Apr. 18	Apr. 3	June 20	July 1	Oct. 17		
4	do.	35	50	1,200	S.	Sandy loam	1904	20	Apr. 15	May 1		May 15		June 20			
16	do.	36	10	3,250	S.	Clay loam	1904	8	May 10	May 17	Apr. 21	Apr. 20	June 25	July 20	Oct. 15	July 20	Aug. 1.
16	do.	36	10	3,250	S.	do.	1905	9	Apr. 21	May 1	May 16	Apr. 15	July 23	do.	Oct. 20	do.	Do.
33	Virginia	37	0	5	None.	Sandy loam	1904	8	Apr. 19	Apr. 25	Apr. 20	Mar. 28	July 9	July 18	Oct. 17	July 18	July 24.
38	do.	37	15	2,170	NW.	Limestone clay	1903	14	Apr. 15	Apr. 20	Apr. 5	Mar. 29			Sept. 14	July -	Aug.
30	do.	37	20	950	SE.	Porous loam	1902	27	Apr. 10	Apr. 25	Apr. 12			July 5	Oct. 27		
78	Delaware	38	45	50	None.	Sandy loam	1904	21	Apr. 24	May 3	Apr. 22	Apr. 13					

TABLE IV.—*Phenological records—Apples*—Continued.

ROME BEAUTY.

Observer's number.	State.	Approximate latitude.		Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
		°	′														
16	North Carolina	36	10	3,250	S.	Clay loam	1904	10	May 12	May 22	Apr. 21	Apr. 25	July 18	Oct. 10	Oct. 15	Nov. 25	May.
16	....do	36	10	3,250	S.	....do	1905	11	May 5	May 10	May 16	Apr. 20	July 21	...do	Oct. 20	...do	Do.
38	Virginia	37	15	2,170	NW.	Limestone clay	1902	13	Apr. 28	May 3	Apr. 18	...do			Sept. 14		
44	....do	37	45	630	SW.	Loam	1904	12	Apr. 26		Apr. –	Apr. 6	June 15				
54	....do	39	0	1,000	NE.	Sandy loam	1902	14	Apr. 25	Apr. 30	Apr. 14	Apr. 18	...do	Sept 15		Sept. 25	Late.
54	....do	39	0	1,000	NE.	....do	1903	15	Apr. 13	Apr. 27	Apr. 5	Apr. 2	June 10	Sept. 25		Oct. 15	Jan.
54	....do	39	0	1,000	NE.	....do	1904	16	May 4	May 10	Apr. 20	Apr. 29	...do				
54	....do	39	0	1,000	NE.	....do	1905	17	Apr. 21	Apr. 27	Apr. 19	Apr. 6	...do	Sept. 20			Late.
54	....do	39	0	1,000	NE.	....do	1906	18	Apr. 27	May 2	May 8	Apr. 16	...do	Sept. 25		Oct. 1	Apr.
54	....do	39	0	1,000	NE.	....do	1907	19	Apr. 26	Apr. 30	Apr. 23	Apr. 4	June 15	Sept. 15		...do	Do.
37	....do	39	10	600	NW.	Clay loam	1903	17	Apr. 18	Apr. 23							
98	New Jersey	40	30	600	S.	Red shale	1905	14		May 11	Apr. 16	Apr. 28		Sept. —	Oct. —		Feb.

ROXBURY. Synonym: *Roxbury Russet*.

Observer's number.	State.	Approximate latitude.		Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
38	Virginia	37	15	2,170	NW.	Limestone clay	1902	13	Apr. 29	May 4	Apr. 18	Apr. 10			Sept. 14		
38	....do	37	15	2,170	NW.	....do	1903	14	Apr. 15	Apr. 28	Apr. 5	Mar. 27		Sept. 25	...do	Oct. 15	Dec.
38	....do	37	15	2,170	NW.	....do	1904	15	May 5	May 12	May 16	Apr. 22	June 22		Oct. 15		
36	....do	38	15	650		Sandy loam	1902	15	Apr. 20	Apr. 24	May 3	Apr. 23			Oct. 17		
48	....do	38	45	375	SE.	Porous loam	1903	25	Apr. 9	Apr. 12	Apr. 5	Apr. 15	July 2	Sept. 15	Oct. 25		Dec.
48	....do	38	45	375	SE.	....do	1905	27	Apr. 24	Apr. 28	Apr. 19	Apr. 26					
48	....do	38	45	375	SE.	....do	1906	60	Apr. 27	Apr. 29	May 11	May 3			Oct. 11	Aug. 1	Dec.
48	....do	38	45	375	SE.	....do	1907		Apr. 28	Apr. 30	Apr. 20			Sept. 20	Oct. 13		Jan.
58	Maryland	39	35	300	S.	Limestone loam	1906	50	Apr. 30	May 4	May 10	Apr. 20		Oct. 1	Oct. 12	Oct. 1	Feb.
58	....do	39	35	300	S.	....do	1907	51	May 3	May 10	May 12	Apr. 23		Oct. 5	Oct. 15	..do	Do.
60	....do	39	35	75	SW.	Heavy loam	1902	25	Apr. 27	May 1	May 28	..do	July 12	..do	Nov. 15	Sept. 1	Late.
60	....do	39	35	75	SW.	....do	1903	26	Apr. 30	May 2	May 20	Apr. 3			Nov. –		
60	....do	39	35	75	SW.	....do	1904	27	May 7	May 9	May 11	May 1	June 30		Sept. 17		Late.
92	New Jersey	40	15	200	S.	Loam	1907	36	..do	May 13	May 22	Apr. 27	June 18	Oct. 1	Oct. –	Jan.	Mar.
104	....do	41	0	600	None.	Clay loam	1904	12	May 10	May 16	Apr. 23	May 4	July 2	Oct. 18	Sept. 22	Mar.	Apr.
104	....do	41	0	600	None.	....do	1905	14	May 6	May 10	Apr. 24	Apr. 27	July 3	Oct. 5	Oct. 22	Dec.	Do.
104	....do	41	0	600	None.	....do	1906	15			May 11	Apr. 26	June 28		Oct. 12		
104	....do	41	0	600	None.	....do	1907	16	May 14	May 18	May 12	Apr. 29	July 3	Oct. 18	Oct. 25	Dec.	Apr.

SHOCKLEY.

6	North Carolina	35	5	200	None.	Sandy loam	1902	......	Apr. 8	Apr. 20	....	Mar. 25	....	....	....	....	....
6	....do	35	5	200	None.	....do	1904	......	Apr. 1	Apr. 7	....	....	....	....	....	....	....
15	....do	35	15	1,700	SE.	Porous loam	1903	8	..do....	..do....	Feb. -	....	....	....	Dec. -	....	....
11	....do	35	25	1,990	SE.	....do	1904	15	Apr. 28	May 4	Apr. 21	May 10	....	Oct. 20	Oct. 24	....	....
11	....do	35	25	1,990	SE.	....do	1905	12	May 1	May 8	May 6	..do....	....	Sept. 5	Oct. 18	Dec.	Mar.
11	....do	35	25	1,990	SE.	....do	1906	15	Apr. 15	Apr. 22	Mar. 10	Apr. 8	....	Oct. 10	....	Nov.	Jan.
11	....do	35	25	1,990	SE.	....do	1907	16	Apr. 10	May 1	Apr. 20	Apr. 20	....	....	Oct. 13	....	Feb.
13	....do	35	25	2,180	NE.	....do	1904	15	May 1	May 10	Apr. 17	Apr. 25	May 30	Oct. -	Oct. 15	Oct. -	Mar.
10d	....do	35	30	4,500	SE.	Sandy loam	1903	12	May 2	May 8	Apr. 28	May 8	July 20	Oct. 1	Oct. 5	Oct. 19	Jan.
38	Virginia	37	15	2,170	NW.	Limestone clay	1902	13	Apr. 30	May 3	Apr. 18	Apr. 10	....	....	Sept. 14	....	....
38	....do	37	15	2,170	NW.	....do	1903	14	Apr. 15	Apr. 27	Apr. 5	Apr. 5	....	Sept. 30	..do....	....	....
38	....do	37	15	2,170	NW.	....do	1904	15	May 6	May 10	May 16	Apr. 16	June 24	....	Oct. 15	....	....
28	....do	37	20	1,000	N.	Porous loam	1904	12	May 15	May 25	May 7	Apr. 17	....	Oct. 20	....	Oct. 20	....
28	....do	37	20	1,000	N.	....do	1906	14	Apr. 17	Apr. 18	Mar. 29	Apr. 3	July 6	....	Nov. 20	....	....
29	....do	37	20	1,000	....	....do	1903	4	Apr. 4	Apr. 10	Apr. 6	Apr. 18	....	Oct. 1	....	Dec.	Mar.
20	....do	38	0	700	S.	Clay loam	1905	30	Apr. 10	Apr. 14	Apr. 18	May 28	....	....	....	....	....

SMITH CIDER.

33	Virginia	37	0	5	SW.	Sandy loam	1904	8	Apr. 19	Apr. 26	Apr. 20	Apr. 1	Aug. 12	Aug. 28	Oct. 17	....	....
38	....do	37	15	2,170	NW.	Limestone clay	1902	13	Apr. 28	May 2	Apr. 18	Apr. 11	....	Sept. 15	Sept. 14	....	....
38	....do	37	15	2,170	NW.	....do	1903	14	Apr. 15	Apr. 20	Apr. 5	Mar. 28	....	Sept. 25	...do....	Oct.	....
38	....do	37	15	2,170	NW.	....do	1904	15	May 1	May 8	May 16	Apr. 21	June 20	....	Oct. 15	....	....
37	....do	39	10	600	NW.	Clay loam	1903	17	Apr. 13	Apr. 21	....	....	....	....	....	....	....
68	Maryland	39	10	550	S.	....do	1906	9	Apr. 21	May 1	May 10	Apr. 18	....	Oct. 1	Oct. 12	Nov. 15	Jan.
65	....do	39	20	75	....	Gravelly loam	1907	9	Apr. 23	Apr. 25	....	Mar. 29	....	Oct. 6	....	Oct. 6	Nov.
65	....do	39	20	75	....	....do	1903	10	Apr. 15	....	....	Mar. 28	....	....	....	Oct. 1	Dec.
64	....do	39	25	225	SE.	Stony loam	1905	25	Apr. 25	Apr. 30	Apr. 19	Apr. 22	Sept. 15	Sept. 1	Oct. 19	Sept. 20	Do.
64	....do	39	25	225	SE.	....do	1906	28	Apr. 30	May 3	May 10	May 3	Sept. 1	....	Oct. 11	....	....
64	....do	39	25	225	SE.	....do	1907	29	Apr. 25	May 7	May 5	Apr. 25	....	....	Oct. 17	....	....
60	....do	39	35	75	SW.	Heavy loam	1902	11	Apr. 27	May 2	May 28	Apr. 23	July 8	Oct. 5	....	....	....
60	....do	39	35	75	SW.	....do	1903	26	Apr. 29	..do....	Apr. 20	Apr. 5	....	....	....	....	....
60	....do	39	35	75	SW.	....do	1904	27	May 8	May 12	May 11	Apr. 29	June 30	Oct. 10	....	....	....
79	New Jersey	39	35	90	NW.	Gravelly loam	1902	50	Apr. 21	Apr. 26	Apr. 15	Apr. 18	....	Sept. 15	....	....	....
89	....do	39	40	150	None.	Porous loam	1904	25	May 5	May 10	Apr. 17	May 1	June 15	Sept. 26	Sept. 25	Feb. [a]	....
59	Maryland	39	40	300	....	Clay loam	1902	20	Apr. 26	Apr. 28	Apr. 15	....	....	....	....	....	....
82	New Jersey	39	55	50	W.	Sandy loam	1902	20	Apr. 24	Apr. 29	....	....	....	Sept. 20	....	Sept. 20	Jan.
86	....do	40	0	50	NW.	Loam	1905	20	May 1	May 7	....	May 10	July 1	Nov. -	Nov. -	Nov. 1	Late.
85	....do	40	0	75	S.	Sandy loam	1907	50	May 5	May 10	May 12	....	....	Oct. 9	Oct. 19	....	Do.
96	....do	40	15	90	N.&S.	Clay loam	1904	25	May 9	May 14	....	May 7	....	Oct. 15	Sept. 17	Oct. 15	Jan.
96	....do	40	15	90	N.&S.	....do	1905	26	May 1	May 6	....	Apr. 15	....	Oct. 13	Oct. 18	Jan.	Feb.
96	....do	40	15	90	N.&S.	....do	1906	27	..do....	....	Apr. -	Apr. 21	....	Oct. 18	Oct. -	Nov. 1	Do.
92	....do	40	15	200	SE.	....do	1906	35	Apr. 26	May 4	May 10	....	....	Oct. 15	Oct. -	Oct.	Apr.
92	....do	40	15	200	SE.	....do	1907	36	May 7	May 12	May 22	Apr. 27	June 15	Oct. 1	Oct. 15	Nov.	Do.
94	....do	40	20	140	S.	Sandy loam	1902	38	Apr. 24	Apr. 29	Apr. 28	Apr. 20	June 27	..do....	Oct. 10	..do....	Dec.
94	....do	40	20	140	S.	....do	1903	39	Apr. 26	May 1	May -	Apr. 9	June 13	..do....	Oct. -	Sept.	Feb.

[a] From cold storage.

TABLE IV.—*Phenological records—Apples*—Continued.

SMITH CIDER—Continued.

Observer's number.	State.	Approximate latitude.	Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
		° ′														
94	New Jersey	40 20	140	S.	Sandy loam	1904	40	May 6	May 11		Apr. 25	July 16	..do	Sept. 20	Oct.	Mar.
94	....do	40 20	140	S.	....do	1905	41	May 1	May 5	Apr. 19			Oct. –		..do	Do.
94	....do	40 20	140	S.	....do	1906	42	May 2	May 9	May –	Apr. 20	June 5	..do	Oct. –	..do	Jan.
94	....do	40 20	140	S.	....do	1907	43	May 8	May 12		May 22	July 3	..do	Oct. 20	..do	Feb.
98	....do	40 30	600	S.	Red shale	1905	14	May 3	May 9	Apr. 16	Apr. 23		Oct. 1	Oct. –		Mar.
100	....do	40 35	600	N.	Clay loam	1903	19	Apr. 22	Apr. 27							
100	....do	40 35	600	N.	....do	1904	20	May 8	May 14	Apr. 22	Apr. 27					
104	....do	41 0	600	None.	....do	1904	12	May 10	...do	Apr. 23	May 2	July 7	Oct. 20	Sept. 22	Feb.	Apr.
104	....do	41 0	600	None.	....do	1906	15	May 9	...do	May 11	Apr. 22	July 4	..do	Oct. 12	..do	Do.
104	....do	41 0	600	None.	....do	1907	16	May 15	May 20	May 12	Apr. 27	July 1	Oct. 26	Oct. 25	Dec.	May.

SMOKEHOUSE.

Observer's number.	State.	Approximate latitude.	Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
38	Virginia	37 15	2,170	NW.	Limestone clay	1902	13	Apr. 24	May 2	Apr. 18	Apr. 13			Sept. 14		
52	....do	37 20	1,200	W.	Porous loam	1902	25	Apr. 16	Apr. 24		Apr. 4					
31	....do	37 25	1,400	NW.	Gravelly loam	1902	6	Apr. 20	...do	Apr. 8	Apr. 21	July –	Sept. 25		Oct. 25	Dec.
50	....do	37 55	200	E.&W.	Sandy loam	1903	16	Mar. 30	Apr. 4		Apr. 5		Aug. 20		Aug. 20	Sept.
35	....do	38 30	400	NE.	Red clay	1902	15	Apr. 23	Apr. 25	Apr. 15	Apr. 4	Aug. 20	July 26	Oct. 22	July 19	Do.
35	....do	38 30	400	NE.	....do	1903	16	Apr. 1	Apr. 10	Apr. 5	Mar. 22	Aug. 7		Oct. 18	July 11	Dec.
35	....do	38 30	400	NE.	....do	1904	17	Apr. 27	May 2	Apr. 23	Apr. 5	Aug. 2		Sept. 23	Aug. 1	Sept.
35	....do	38 30	400	NE.	....do	1905	18	Apr. 12	Apr. 19	Apr. 20	Mar. 28	July 17	Aug. 10	Oct. 13	July 15	Do.
35	....do	38 30	400	NE.	....do	1906	19	Apr. 19	Apr. 25	May 10	Apr. 9	July 29		Oct. 11	July 22	Do.
48	....do	38 45	375	S.	Porous loam	1906	30	Apr. 27	Apr. 29	May 11	Apr. 30			..do	July 25	Do.
55	....do	39 0	600	E.	....do	1907	14	Apr. 20	May 1	May 9	Mar. 26		Sept. 1	Oct. 10	Oct.	Dec.
37	....do	39 10	600	NW.	Clay loam	1903	17	Apr. 14	Apr. 20							
60	Maryland	39 35	75	SW.	Heavy loam	1902	25	Apr. 27	May 2	May 28	Apr. 22	July 10	Sept. 16	Nov. 15	July 15	
60	....do	39 35	75	SW.	....do	1903	26	Apr. 25	Apr. 28	Apr. 20	Apr. 3			Nov. –		
60	....do	39 35	75	SW.	....do	1904	27	May 9	May 10	May 11	Apr. 29	June 30		Sept. 17		
60a	....do	39 35	125	SW.	Sandy loam	1902	35	Apr. 26	Apr. 28	Apr. 20	Apr. 20	July 10	Aug. 25	Nov. 15	July 1	Dec.
60a	....do	39 35	125	SW.	....do	1903	36	Apr. 15	Apr. 23	..do	Apr. 1		Oct. 3	Nov. –		Do.
60a	....do	39 35	125	SW.	....do	1904	37	Apr. 30	May 7	Apr. 21	Apr. 22	July 5	Sept. 20	Sept. 17		Do.
85	....do	40 0	75	None.	....do	1907	50	May 1	May 6	May 12			Oct. 9	Oct. 19	Sept. 5	Oct.
82	New Jersey	39 55	50	W.	....do	1902	6	Apr. 23	Apr. 29				Sept. 1		Sept. 1	Do.
82	....do	39 55	50	W.	....do	1903	7	Apr. 16								
84	....do	39 55	50	N.	Heavy loam	1902	35	Apr. 25	Apr. 30	Apr. 16	Apr. 18	Aug. 15	Sept. 1	Oct. 10	Sept. 10	Jan.
84	....do	39 55	50	N.	....do	1903	36	Apr. 20	Apr. 25	May 2	Apr. 5	Aug. 1	..do	Oct. –	Sept. 1	Do.
86	....do	40 0	50	NW.	Loam	1905	20	May 1	May 6		May 10	July 1	Sept. 15	Nov. –	Sept. 15	Nov.

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48	Virginia	38	45	350	SE.	Porous loam	1907		Apr. 26	Apr. 28	Apr. 20				Oct. 13		
75	Delaware	39	0	60	None.	Sandy loam	1906	10	Apr. 22	..do	Apr. 3	Apr. 18		Oct. 1	Oct. –	Nov.	Jan.
72	....do	39	10	70	None.	....do	1902	10	Apr. 23	Apr. 20				Oct. 10	Oct. 10	Nov. 1	
68	Maryland	39	10	550	S.	Porous loam	1906	9	Apr. 19	May 1	May 10	Apr. 15		Oct. 1	Oct. 12	Nov. 15	May.
65	....do	39	20	75		Gravelly loam	1902	7	Apr. 23	Apr. 28		Mar. 9		Oct. 13		Oct. 6	Jan.
65	....do	39	20	75		....do	1903	8	Apr. 15	Apr. 22		May 28				Nov. 15	Feb.
82	New Jersey	39	55	50	W.	Sandy loam	1902	6	Apr. 24	Apr. 30				Sept. 25		Sept. 25	Jan.

SUMMER HAGLOE. Synonym: *Hagloe.*

72	Delaware	39	10	70	None.	Sandy loam	1902	10	Apr. 26	Apr. 29				Aug. 1	Oct. 20	Aug. 10	
89	New Jersey	39	40	150	None.	Gravelly loam	1904	25	May 8	May 12	Apr. 17	May 5	June 15	..do	Sept. 25	Aug. 1	
82	....do	39	55	50	W.	Sandy loam	1902	19	Apr. 24	Apr. 29				July 17		July 17	Aug.
82	....do	39	55	50	W.	....do	1903	20	Apr. 21								
80	....do	40	5	60	N.	Gravelly loam	1904	40	May 6	May 19	Apr. 24		June 1	Aug. 25	Oct. 10	Aug. 10	

TETOFSKI.

38	Virginia	37	15	2,170	NW.	Limestone clay	1903	14	Apr. 13	Apr. 26	Apr. 15	Apr. 11			Sept. 14		
38	....do	37	15	2,170	NW.	....do	1904	15	May 6	May 13	May 16	Apr. 22	July 2		Oct. 15		
100	New Jersey	40	35	600	N.	Clay loam	1903	19	Apr. 25			Apr. 1					
100	....do	40	35	600	N.	....do	1904	20	May 3	May 12	Apr. 22	Apr. 27		Aug. 9		Aug. 10	Aug. 15.

TOMPKINS KING. Synonym: *King.*

38	Virginia	37	15	2,170	NW.	Limestone clay	1903	14	Apr. 14	Apr. 20	Apr. 5	Apr. 17		Sept. 20	Sept. 14		
38	....do	37	15	2,170	NW.	....do	1904	15	May 8	May 12	May 16	Apr. 19	June 25		Oct. 15		
48	....do	38	45	375	S.	Porous loam	1906	30	Apr. 26	Apr. 28	May 11	May 1			Oct. 11		Oct.
54	....do	39	0	1,000	NE.	....do	1902	8	Apr. 24	..do	Apr. 14	Apr. 14	June 20	Sept. 20		Nov. 1	
104	New Jersey	41	0	600	None.	Clay loam	1904	12	May 10	May 14	Apr. 23	May 3	July 2	Sept. 30	Sept. 22	..do	Jan.
104	....do	41	0	600	None.	....do	1906	15	May 8	May 13	May 11	Apr. 22	June 30	Oct. 1	Oct. 12	Feb.	Apr.
104	....do	41	0	600	None.	....do	1907	16	May 14	May 20	May 12	Apr. 26	July 7	..do	Oct. 25	Nov.	Feb.
101	....do	41	10	550	SE.	Gravelly loam	1904	18	May 8	May 15	Apr. 23	Apr. 24			Sept. 22		
102	....do	41	10	800	None.	Sandy loam	1904	23	May 10	..do							
102	....do	41	10	800	None.	....do	1905	24	May 7	May 11		Apr. 18					

TABLE IV.—*Phenological records—Apples*—Continued.

VIRGINIA BEAUTY.

Observer's number.	State.	Approximate latitude.	Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
		° ′														
16	North Carolina	35 30	2,875	S.	Clay loam	1902	12	Apr. 28	May 8	Apr. 1	May 4	July 30	Oct. 20	Oct. 15	Dec. 1	Feb.
10c	do	35 30	4,000	NE.	do	1902	6	do	May 6	Apr. 25	May 7	July 24	Oct. 10	Oct. 3	Nov. 25	Dec.
10d	do	35 30	4,500	SE.	Sandy loam	1902	12	May 1	do	Apr. 22		July 27	Oct. 21	Oct. 1	Dec. 1	Jan.
4	do	35 50	1,200	S.	do	1904	12	Apr. 15	May 1		May 15		Oct. –		Sept. –	
16	do	36 10	3,250	S.	Clay loam	1904	10	May 8	May 15	Apr. 21	Apr. 24	July 29	Oct. 5	Oct. 15	Nov. 1	Feb.

WEALTHY.

Observer's number.	State.	Approximate latitude.	Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
38	Virginia	37 15	2,170	NW.	Limestone clay	1903	14	Apr. 15	Apr. 27	Apr. 5	Mar. 30		Sept. 20	Sept. 14	Oct. 5	
38	do	37 15	2,170	NW.	do	1904	15	May 6	May 13	May 16	Apr. 21	June 27		Oct. 15		
72	Delaware	39 10	70	None.	Sandy loam	1902	7	Apr. 25	Apr. 28				Sept. 5	Oct. 20		
82	New Jersey	39 55	50	W.	do	1902	6	Apr. 24	Apr. 27				Aug. 15		Aug. 15	Sept. 15.

WILLIAMS.

Observer's number.	State.	Approximate latitude.	Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
38	Virginia	37 15	2,170	NW.	Limestone clay	1903	14	Apr. 16	Apr. 29	Apr. 5	Mar. 30			Sept. 14		
38	do	37 15	2,170	NW.	do	1904	15	May 7	May 14	May 16	Apr. 26	June 28		Oct. 15		
76	Delaware	39 5	40	NE.	Sandy loam	1903	12	Apr. 20	Apr. 28	Apr. 6	Apr. 1	June 16	July 13			July. 27.
76	do	39 5	40	NE.	do	1904	13	May 5	May 7	Apr. 21	Apr. 28	June 23	July 23	Oct. 28	July 28	
76	do	39 5	40	NE.	do	1905	14	Apr. 26	Apr. 29	Apr. 19	Apr. 4	June 14	July 24	Oct. 22		
72	do	39 10	70	None.	do	1902	7	Apr. 25	Apr. 28				July 10	Oct. 20	July 10	
82	New Jersey	39 55	50	W.	do	1902	6	Apr. 24	Apr. 30				July 15		July 11	Aug. 1.
86	do	40 0	50	NW.	Loam	1905	20	May 1	May 7			July 1	July 25	Nov. –	July 15	Do.
80	do	40 5	60	N.	Gravelly loam	1904	24	May 7		Apr. 24		June 1	July 15	Oct. 10	do	
80	do	40 5	60	N.	do	1905	25	May 1	May 5	Apr. 19	Apr. 21	June 15	July 25	Oct. 15	July 25	
80	do	40 5	60	N.	do	1906	26	Apr. 20	do	Apr. 6		June 14	Aug. 1		July 14	
80	do	40 5	60	N.	do	1907	30	May 10	May 20	Apr. 20	Apr. 27	July 1	July 25			
99	do	40 35	40	NW.	Sandy loam	1907	25	do	May 14	May 12	May 3	Sept. 15	July 30	Oct. 5	July –	Aug.

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WINESAP

15	North Carolina	35	15	1,700	SE.	Porous loam	1903	8	Apr. 3	Apr. 11	Feb. -				Dec. -		
7	....do	35	20	700	None.	Loam	1905	10	Mar. 25	Apr. 5	Apr. 17	Mar. 18			Oct. 11		
11	....do	35	25	1,990	SE.	Porous loam	1904	20	Apr. 28	May 3	Apr. 21	May 8		Oct. 10	Oct. 24	Nov. 1	Dec.
11	....do	35	25	1,990	SE.	....do	1906	22	Apr. 10	Apr. 18	May 10	Apr. 5		..do	Oct. 10	..do	Jan.
11	....do	35	25	1,990	SE.	....do	1907	15	..do	May 1	Apr. 20	Apr. 15			Oct. 13		Dec.
12	....do	35	25	2,130	W.	....do	1902	17	Apr. 24	..do	Apr. 5	Apr. 22	July 4	Sept. 30	Oct. 15	Oct. 15	May.
12	....do	35	25	2,130	W.	....do	1903	18	Apr. 8	Apr. 13	Apr. 6	Apr. 13	July 6				
12	....do	35	25	2,130	W.	....do	1904	19	Apr. 17	Apr. 28	Apr. 11	Apr. 27		Oct. 1	Oct. 15	Dec. 20	Apr.
12	....do	35	25	2,130	W.	....do	1905	20	Apr. 6	Apr. 14	Apr. 7	Apr. 20	July 24	..do	Oct. 14	Dec. -	Do.
13	....do	35	25	2,180	NE.	Porous clay	1904	15	May 1	May 10	Apr. 17	Apr. 25	May 30	Oct. -	Oct. 15	Sept. 15	Mar.
2	....do	35	30	2,900	E.	Clay loam	1904	8	Apr. 17	Apr. 28		Apr. 7		Nov. 12	Oct. 14		
2	....do	35	30	2,900	E.	....do	1905	9	Apr. 5	Apr. 13	Apr. 18	Apr. 3	July 24		Oct. 17		
10	....do	35	30	2,875	SW.	....do	1902	12	Apr. 30	May 10	Apr. 1	May 5	July 31	Oct. 15	Oct. 15	Dec. 25	Feb.
10	....do	35	30	2,875	SW.	....do	1903	7	Apr. 4	Apr. 14	Apr. 28	Apr. 1	July 12	..do	Oct. 25	Dec. 10	Do.
10	....do	35	30	2,875	SW.	....do	1904	8	Apr. 15	Apr. 25	Apr. 1	Mar. 23	June 30	Oct. 20	Oct. 16	Nov. 1	Do.
10	....do	35	30	2,875	SW.	....do	1905	9			Mar. 10	Mar. 28	July 2	..do		Dec. 10	
10	....do	35	30	2,875	SW.	....do	1906	10	Mar. 28	Apr. 10	Apr. 15	..do	July 15	Nov. 15	Oct. 14	Dec. -	Mar.
10a	....do	35	30	3,300	NE.	....do	1902	6	Apr. 21	Apr. 27	..do	Apr. 21	July 31	Oct. 20	Oct. 5	Nov. 20	Jan.
10b	....do	35	30	3,500	SE.	Gravelly clay	1902	12	Apr. 29	May 8	Apr. 20	May 7	July 30	..do	Oct. 3	Dec. 20	Mar.
10c	....do	35	30	4,000	NE.	Clay loam	1902	6	May 1	..do	Apr. 25	May 9	July 26	Oct. 15	..do	Dec. 1	Feb.
10d	....do	35	30	4,500	SE.	Sandy loam	1902	13	Apr. 25	May 3	Apr. 22	May 8	July 30	Oct. 20	Oct. 1	Nov. 20	Jan.
10d	....do	35	30	4,500	SE.	....do	1903	14	May 3	May 10	Apr. 28	May 9	July 18	..do	Oct. 5	Dec. 1	May.
1	....do	35	35	2,300	S.	Loam	1904	12	Apr. 15	Apr. 28		Apr. 3			Oct. 15		
1	....do	35	35	2,300	S.	....do	1905	13	Apr. 5	Apr. 15	Apr. 16	Mar. 27		Oct. 15	Oct. 16	Jan. 1	
4	....do	35	50	1,200	S.	Sandy loam	1904	20	Apr. 15	May 1		May 15					
5	....do	35	50	1,500	N.	Loam	1905	20	..do	Apr. 20	Mar. 30	Mar. 25	May 5	Oct. 25	Oct. -	Oct. 10	Apr.
8	....do	36	5	900	S.	Sandy	1905	15	Apr. 3	..do							
47	Virginia	36	45	1,700	SE.	Black loam	1905		Apr. 15	May 1	May 1			Sept. 25		Nov. 1	Apr.
33	....do	37	5	5	SW.	Sandy loam	1903	7			Apr. 5	Mar. 25	Aug. 20		Oct 27		
33	....do	37	5	5	SW.	....do	1904	8	Apr. 24	Apr. 29	Apr. 20	Apr. 4	June 23	Aug. 15	Oct. 17		
48	....do	37	5				1907	21	Apr. 29	May 8	..do	Apr. 30		Sept. 28	Oct. 15	Sept. 15	Mar.
40	....do	37	10	2,400	None.	Porous loam	1907	8	Apr. 10	Apr. 26	Apr. 5						
39	....do	37	10	2,000	NW.	Dark loam	1902	8	Apr. 25	May 3	May 18			Oct. 20	Sept. 10	Jan. 10	Apr.
26	....do	37	15	900	N.	Sandy loam	1902	15	Apr. 21	Apr. 26			June 20			Jan. 25	
26	....do	37	15	900	N.	....do	1903	16	Apr. 4	Apr. 12							
46	....do	37	15	500	S.	....do	1903	16	Apr. 1							Sept. 20	Mar.
38	....do	37	15	2,170	NW.	Limestone clay	1902	13	Apr. 28	May 3	Apr. 18	Apr. 12		Sept. 25	Sept. 14		
38	....do	37	15	2,170	NW.	....do	1903	14	Apr. 30	May 15	Apr. 5	Apr. 5		Sept. 30	..do		
38	....do	37	15	2,170	NW.	....do	1904	15	May 7	May 12	May 16	Apr. 23	June 24		Oct. 15		
28	....do	37	20	1,000	N.	Porous loam	1904	5	May 15	May 25	May 7			Oct. 20		Oct. 20	Late.
28	....do	37	20	1,000	N.	....do	1905	10	Apr. 6	Apr. 20	Mar. 28	Apr. 3	June 19	Sept. 24	Oct. 13	..do	Do.
28	....do	37	20	1,000	N.	....do	1906	11	Apr. 12	Apr. 21	May 29	Apr. 10	July 10		Nov. 20		
28	....do	37	20	1,000	N.	....do	1907	12	Apr. 4	Apr. 27	May 7	Mar. 27	June 18	Oct. 8	Nov. 4	Oct. 25	Late.
52	....do	37	20	1,200	W.	Clay loam	1902	20	Apr. 17	Apr. 25		Apr. 10					
25	....do	37	20	1,000	SE.	....do	1902	15	Apr. 15	Apr. 20	Mar. 20	Apr. 15	July 15	Oct. 15	Oct. 20	Dec. 1	Apr.
25	....do	37	20	1,000	SE.	....do	1903	16	Apr. 20	May 1	Apr. 20	Apr. 20	July 20	Oct. 10	Oct. 15	Nov. 15	Do.
25	....do	37	20	1,000	SE.	....do	1904	17	May 1	May 10	May 5	May 1	July 10	..do	Oct. 10	..do	Do.
25	....do	37	20	1,000	SE.	....do	1905	18	Apr. 25	May 5	Apr. 15	Apr. 25	July 20	Oct. 20	Oct. 20	..do	Do.

TABLE IV.—*Phenological records—Apples*—Continued.

WINESAP—Continued.

Observer's number.	State.	Approximate latitude.	Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
		° ′														
29	Virginia	37 20	1,200	SE.	Porous loam	1903	10	Apr. 7	Apr. 16	Apr. 6	Apr. 20		Oct. 1		Oct. -	Feb.
31	do	37 25	1,400	NW.	Gravelly loam	1902	12	Apr. 24	Apr. 26	Apr. 8	Apr. 23	July -	Sept. 28		Nov. 15	Late.
27	do	37 30	1,000	NE.	Clay loam	1902	26	Apr. 19	Apr. 22	Mar. -	Apr. 9		Sept. 25	Nov. -	Nov. -	Feb.
44	do	37 45	630	SW.	Loam	1904	12	Apr. 25		Apr. -	Apr. 4	June 15				
42	do	37 45	800	SE.	Clay loam	1903	2	Apr. 4	Apr. 15	Apr. 15	Apr. 25		Sept. 15		Dec. 15	June.
43	do	37 50	1,000	SE.	do	1903	6	Apr. 5	Apr. 18	Apr. 5	Apr. 20	June 1	Oct. 10	Oct. 27	Oct. -	May.
45	do	37 50	1,000			1906	15	Apr. 16	Apr. 20	May 9	Apr. 10		Oct. 1	Oct. 10	Nov.	Do.
44a	do	37 50	1,000			1907	26	Apr. 1	do	Apr. -			do		Dec.	Apr.
21	do	37 55	500	SE.	Clay	1904	20	Apr. 24	Apr. 26		Apr. 10		Sept. 1			
20	do	38 0	700	S.	do	1905	30	Apr. 10	Apr. 14	Apr. 18	Mar. 29					
41	do	38 0	1,200	N.	Clay loam	1903	19	Apr. 5	Apr. 11	Apr. 5	Mar. 25		Oct. 14	Oct. 15	Dec. 15	Apr.
71	Maryland	38 5	20	SE.	Red clay	1902	8		Apr. 27		Apr. 10		Nov. 1		Dec. 1	Feb.
19	Virginia	38 5	900	S.	do	1905	8	Apr. 13	Apr. 23	Apr. 19	Apr. 2		Sept. 19	Oct. 7	Oct. -	
19	do	38 5	900	S.	do	1905	19	Apr. 11	Apr. 22	do	Mar. 29		do	do	do	
18	do	38 10	1,000	W.	Sandy loam	1902	16						Sept. 25	Oct. 5	Nov. 15	Feb.
18	do	38 10	1,000	W.	do	1903	17	Apr. 4	Apr. 13	Apr. 7	Apr. 30		Oct. 1	Oct. 20	Nov. 1	Dec.
22	do	38 10	1,200	NE.	Gravelly loam	1907	20	Apr. 23	Apr. 30	May 22	Mar. 28		Oct. 15	Oct. 9	Feb. -	Apr.
36	do	38 15	650		Sandy loam	1902	15	Apr. 18	Apr. 23	May 3	Apr. 18			Oct. 17		
53	do	38 25	1,400	W.	Gravelly loam	1902	16	Apr. 26	Apr. 30		Apr. 14		Sept. 30		Dec. -	Mar.
53	do	38 25	1,400	W.	do	1903	17	Apr. 12	Apr. 22		Apr. 8		Oct. -		do	Do.
53	do	38 25	1,400	W.	do	1905	19	Apr. 21	Apr. 27	Apr. 24	Apr. 6		Oct. 1		Oct. -	Do.
53	do	38 25	1,400	W.	do	1906	20	Apr. 25	May 2	May 11	Apr. 17		do	Oct. 8	do	Do.
35	do	38 30	400	NE.	Red clay	1902	15	Apr. 23	Apr. 27	Apr. 15	Apr. 16	Aug. 16	Oct. 15	Oct. 22	Oct. 1	Apr.
35	do	38 30	400	NE.	do	1903	16	Apr. 7	Apr. 14	Apr. 5	Mar. 27	Aug. 5	Oct. 1	Oct. 18	Sept. 1	Do.
35	do	38 30	400	NE.	do	1904	17	May 1	May 6	Apr. 23	Apr. 9	Aug. 4	Sept. 26	Sept. 23	do	Do.
35	do	38 30	400	NE.	do	1905	18	Apr. 13	Apr. 21	Apr. 20	Mar. 31	July 18		Oct. 13	do	Do.
35	do	38 30	400	NE.	do	1906	19	Apr. 22	Apr. 29	May 10	Apr. 11	July 29		Oct. 11	do	Do.
61	Maryland	38 40	45	None.	Sandy loam	1907	15	Apr. 15	Apr. 28							
78	Delaware	38 45	50	SE.	do	1904	21	Apr. 29	May 4	Apr. 22	Apr. 13					
34	Virginia	38 45	300	W.	Clay loam	1902	13			May 30			Oct. 18	Sept. 18	Sept. 1	Jan.
48	do	38 45	375	SE.	Porous loam	1903	15	Apr. 10	Apr. 15	Apr. 5	Apr. 18	June 30	Sept. 15	Oct. 25	Jan. -	Mar.
48	do	38 45	375	SE.	do	1906	33	Apr. 27	Apr. 29	May 11	May 2			Oct. 11	Sept. 1	Do.
48	do	38 45	375	SE.	do	1907	34	do	Apr. 30	Apr. 20				Oct. 13		
54	do	39 0	1,000	NE.	do	1902	14	Apr. 24	Apr. 29	Apr. 14	Apr. 17	June 15	Sept. 25		Sept. 1	Late.
54	do	39 0	1,000	NE.	do	1903	15	Apr. 10	Apr. 22	Apr. 5	May 30	June 10	Sept. 30		Dec. 1	Do.
54	do	39 0	1,000	NE.	do	1904	16	May 3	May 9	Apr. 20	Apr. 27	do				

54	....do....	39	0	1,000	NE.	....do....	1905	17	Apr. 19	Apr. 26	Apr. 19	Apr. 10	...do....				
54	....do....	39	0	1,000	NE.	....do....	1906	18	Apr. 25	Apr. 30	May 8	Apr. 18	...do....	Oct. 1	....	Oct. 1	Apr.
54	....do....	39	0	1,000	NE.	....do....	1907	19	Apr. 20	Apr. 20	Apr. 23	Mar. 30	...do....	...do....	....	Dec. 1	June.
55	....do....	39	0	600	E.	Sandy loam....	1907	14	Apr. 21	Apr. 25	May 8	Mar. 29	....	...do....	Oct. 10	Jan. -	Mar.
57	Maryland....	39	0	75	None.	Sandy....	1907	25	Apr. 20	May 6	Apr. 18	Apr. 4	....	....	....	....	....
72	Delaware....	39	10	70	None.	Sandy loam....	1902	30	Apr. 24	Apr. 26	....	....	....	Oct. 25	Oct. 20	Nov. 15	....
73	....do....	39	10	100	N.	....do....	1902	20	Apr. 28	May 4	....	Apr. 10	....	Nov. 1	....	Dec. 20	Jan.
74	....do....	39	10	80	None.	Clay loam....	1903	14	Apr. 18	Apr. 25	Apr. 6	....	....	Oct. 1	Oct. 22	Dec. -	....
37	Virginia....	39	10	600	NW.	....do....	1903	17	Apr. 17	Apr. 23	....	....	....	....	....	....	....
87	New Jersey....	39	15	40	SW.	Sandy loam....	1902	10	Apr. 30	May 7	....	Apr. 24	....	....	....	....	....
67	Maryland....	39	20	50	E.	....do....	1903	8	Apr. 10	Apr. 15	Apr. 6	Apr. 7	....	Oct. 15	Oct. 26	Nov. 1	Dec.
64	....do....	39	25	225	SE.	Stony loam....	1905	25	Apr. 28	Apr. 30	Apr. 19	Apr. 26	Sept. 1	...do....	Oct. 19	Dec. 15	Mar.
64	....do....	39	25	225	SE.	....do....	1906	26	Apr. 30	May 3	May 10	May 2	Aug. 15	....	Oct. 11	....	....
64	....do....	39	25	225	SE.	....do....	1907	27	Apr. 28	May 8	May 5	May 1	....	....	Oct. 17	....	....
60	....do....	39	35	75	SW.	Heavy loam....	1902	25	...do....	May 1	May 28	Apr. 23	July 12	Sept. 16	Nov. 15	Sept. 1	Late.
60	....do....	39	35	75	SW.	....do....	1903	26	Apr. 30	May 2	Apr. 20	Apr. 3	....	....	Nov. -	....	....
60	....do....	39	35	75	SW.	....do....	1904	27	May 6	May 9	May 11	May 2	July 4	Oct. 5	Sept. 17	....	Late.
79	New Jersey....	39	35	90	NNW.	Gravelly loam....	1902	50	Apr. 24	Apr. 29	Apr. 15	Apr. 21	....	Sept. 20	Nov. 15	Sept. 10	....
89	....do....	39	40	150	None.	....do....	1904	10	May 8	May 12	Apr. 17	May 4	June 15	Oct. 1	Sept. 25	Apr. 1[a]	....
91	....do....	39	50	....	....	....	1906	3	Apr. 30	May 1	....	Apr. 14	July 20	Oct. 15	....	Oct. 1	Apr.
82	....do....	39	55	50	W.	Sandy loam....	1902	20	Apr. 24	Apr. 28	....	....	....	Sept. 25	....	Sept. 25	Dec.
94	....do....	40	20	140	S.	....do....	1902	38	...do....	May 1	Apr. 28	Apr. 20	June 27	Oct. 1	Oct. 10	Nov. -	Feb.
94	....do....	40	20	140	S.	....do....	1904	40	May 8	May 11	....	Apr. 30	July 16	...do....	Sept. 20	Dec. -	Apr.
94	....do....	40	20	140	S.	....do....	1905	41	Apr. 30	May 4	Apr. 19	....	....	Oct. -	....	Sept. -	Do.
94	....do....	40	20	140	S.	....do....	1906	42	May 3	May 8	....	Apr. 21	June 5	Oct. 1	Oct. -	Oct. -	June.
94	....do....	40	20	140	S.	....do....	1907	43	May 1	May 14	....	Apr. 26	July 4	Nov. 1	Oct. 20	...do....	Feb.
99	....do....	40	35	40	NW.	....do....	1907	12	May 12	....	May 12	May 1	....	Oct. 15	Oct. 5	....	May.
104	....do....	41	0	600	None.	Clay loam....	1905	16	May 7	May 11	Apr. 24	Apr. 25	July 1	Oct. 17	Oct. 22	Jan. 1	Do.

WINTER PARADISE. Synonym: *Sweet Winter Paradise.*

28	Virginia....	37	20	1,000	N.	Clay loam....	1904	12	May 12	May 18	May 7	....	....	Oct. 20	....	Sept. 15	....
29	....do....	37	20	1,200	SE.	....do....	1903	25	Apr. 10	Apr. 15	Apr. 6	Apr. 15	....	Aug. 20	....	Oct. -	Dec.
35	....do....	38	30	400	NE.	Red clay....	1902	15	Apr. 20	Apr. 27	Apr. 15	Mar. 31	Aug. 10	Sept. 26	Oct. 22	Sept. 1	Jan.
35	....do....	38	30	400	NE.	....do....	1903	16	Mar. 31	Apr. 5	Apr. 5	Mar. 23	Aug. 1	Sept. 15	Oct. 18	Aug. 10	Nov.
35	....do....	38	30	400	NE.	....do....	1904	17	Apr. 30	May 5	Apr. 23	Apr. 4	July 27	...do....	Sept. 23	Sept. 10	Jan.
35	....do....	38	30	400	NE.	....do....	1905	18	Apr. 13	Apr. 22	Apr. 20	Mar. 29	July 18	....	Oct. 13	Sept. 1	....
35	....do....	38	30	400	NE.	....do....	1906	19	Apr. 20	Apr. 25	May 10	Apr. 11	July 24	Sept. 1	Oct. 11	Aug. 15	Oct.
54	....do....	39	0	1,000	NE.	Porous loam....	1903	20	Apr. 9	Apr. 21	Apr. 5	Mar. 28	June 10	Sept. 25	....	Oct. 1	Dec.
54	....do....	39	0	1,000	NE.	....do....	1905	17	Apr. 18	Apr. 25	Apr. 19	Apr. 6	...do....	...do....	....	....	....

[a] From cold storage.

TABLE IV.—*Phenological records—Apples*—Continued.

YELLOW NEWTOWN. Synonym: *Albemarle Pippin.*

Observer's number.	State.	Approximate latitude.	Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
10	North Carolina	35° 30′	2,875	SW.	Clay loam	1905	8			Mar. 10	Mar. 28	July 5	Oct. 28		Nov. 20	Jan.
10d	do	35 30	4,500	SE.	Sandy loam	1902	12	May 1	May 6	Apr. 22		July 31	Oct. 25	Oct. 1	do	Dec.
47	Virginia	36 45	1,700	SE.	Black loam	1905		Apr. 15	May 1	May 1				do	Dec. 20	Apr.
51	do	37 10	2,900	SE.	Sandy loam	1905	25	May 5		Apr. 16	Apr. 10		Oct. 1	Oct. 20	Nov. 20	Do.
52	do	37 20	1,200	W.	Clay loam	1902	25	Apr. 10	Apr. 25		do					
29	do	37 20	1,200	SE.	do	1903	20	do	Apr. 19	Apr. 6	Apr. 25		Oct. 15		Dec. -	Mar.
44	do	37 45	630	SW.	Loam	1904	15	Apr. 25		Apr. -	Apr. 10	June 15				
42	do	37 45	800	SE.	Red clay	1903	20	Apr. 6	Apr. 15	Apr. 15	Apr. 25		Sept. 15		Jan. -	June.
44a	do	37 50	1,200	NW.	Porous loam	1907	26	Apr. 1	Apr. 20	Apr. -			Oct. 1		Dec. -	Apr.
45	do	37 50	1,200			1906	15	Apr. 19	Apr. 21	May 9	Apr. 14			Oct. 10		
41	do	38 0	1,200	N.	Black loam	1903	19			Apr. 5	May 25		Sept. 18	Oct. 15	Mar. -	May.
54	do	39 0	1,000	NE.	Porous loam	1902	6	Apr. 24	Apr. 29	Apr. 14	Apr. 16	June 20				

YELLOW TRANSPARENT.

Observer's number.	State.	Approximate latitude.	Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
17	North Carolina	36 15	3,000	SE.	Clay loam	1904	8	Apr. 20	Apr. 25	May 3	Mar. 20		July 20	Oct. 11	June 10	
40	Virginia	37 10	2,400	None.	Porous loam	1907	8	Apr. 15	Apr. 20	Apr. 5						
26	do	37 15	900	NW.	Sandy loam	1902	7	Apr. 21	Apr. 28							
26	do	37 15	900	NW.	do	1903	8	Apr. 6	Apr. 11			June 1	June 10		June 10	July 15.
38	do	37 15	2,170	NW.	Limestone clay	1902	13	Apr. 28	May 2	Apr. 18	Apr. 10			Sept. 14		
38	do	37 15	2,170	NW.	do	1903	14	Apr. 15	Apr. 26	Apr. 5	Apr. 8			do		
28	do	37 20	1,000	N.	Clay loam	1904	8	May 4	May 14	May 7	Apr. 17		July 20		July 20	Aug. 20.
28	do	37 20	1,000	N.	do	1906	10	Apr. 14	Apr. 16	Mar. 29	Apr. 2	July 2		Nov. 20		
29	do	37 20	1,200	SE.	do	1903	6	Mar. 26	Apr. 8	Apr. 6	Apr. 10					
27	do	37 30	1,000	NE.	do	1902	5	Apr. 21	Apr. 24	Mar. -	Apr. 8		July -	Nov. -	July 10	
50	do	37 55	200	E.&W.	Sandy loam	1902	15	Apr. 17	Apr. 23	Apr. 9	Apr. 10		do	Oct. 30	July -	Aug. 30.
50	do	37 55	200	E.&W.	do	1903	16	Mar. 28	Apr. 2		Apr. 15		do		July 5	Aug. 1.
50	do	37 55	200	E.&W.	do	1904	17	Apr. 20	Apr. 25	Apr. 6	Apr. 25		July 10	Sept. 7		
50	do	37 55	200	E.&W.	do	1905	18	Apr. 9	Apr. 14	Apr. 19	Apr. 14		do	Oct. 22	July 10	Aug. 1.
50	do	37 55	200	E.&W.	do	1906	19	Apr. 15	Apr. 25	May 11	Apr. 25		do	do		Do.
35	do	38 30	400	NE.	Red clay	1902	4	Apr. -		Apr. 15	Apr. 15	Aug. 24				
35	do	38 30	400	NE.	do	1903	5	Apr. 7	Apr. 12	Apr. 5	Mar. 28	Aug. 1	June 29	Oct. 18	June 21	July 27.
35	do	38 30	400	NE.	do	1904	6	Apr. 27	May 6	Apr. 23	Apr. 7	July 12	July 18	Sept. 23	June 23	Aug. 6.
35	do	38 30	400	NE.	do	1905	7			Apr. 20	Apr. 2	July 22		Oct. 13		

85	do.	38	30	400	NE.	do.	1906	8	Apr. 25	Apr. 29	May 10	Apr. 15	July 21		Oct. 11		
78	Delaware	38	45	50	None.	Sandy loam	1904	8	Apr. 29	May 4	Apr. 22	Apr. 12					
48	Virginia	38	45	375	SE.	Porous loam	1903	11	Apr. 8	Apr. 12	Apr. 5	Apr. 17	June 30	July 6	Oct. 25		July 25.
48	do.	38	45	375	SE.	do.	1905	13	Apr. 21	Apr. 23	Apr. 19	Apr. 21					
48	do.	38	45	375	SE.	do.	1906	25	Apr. 23	Apr. 26	May 11	May 1		June 30	Oct. 11	June 30	July 20.
48	do.	38	45	375	SE.	do.	1907	26	Apr. 27	Apr. 29	Apr. 20			July 20	Oct. 13		Aug. 15.
54	do.	39	0	1,000	NE.	do.	1904	10	May 3	May 9	do.	Apr. 26					
54	do.	39	0	1,000	NE.	do.	1906	18	Apr. 26	Apr. 30	Apr. 24	Apr. 18	June 10	July 1		June 25	Aug.
76	Delaware	39	5	40	NE.	Sandy loam	1903	10	Apr. 11	Apr. 18	Apr. 6	Mar. 28	June 8	June 24			
76	do.	39	5	40	NE.	do.	1904	11	May 2	May 6	Apr. 21	Apr. 23	June 23	July 1	Oct. 28		
76	do.	39	5	40	NE.	do.	1905	12	Apr. 20	Apr. 24	Apr. 19	Apr. 3	June 9	June 30	Oct. 22		
74	do.	39	10	70	None.	do.	1902	10	Apr. 24	Apr. 27				June 25	Oct. 20	June 25	
73	do.	39	10	100	N.	do.	1902	10	Apr. 25	May 1		Apr. 13		do.		July 1	
87	New Jersey	39	15	40	SW.	do.	1902	10	Apr. 30	May 5		Apr. 24					
66	Maryland	39	20	75	N.	Clay loam	1903	6	Apr. 15	Apr. 24	Apr. 7	Apr. 9		July 6		July -	
65	do.	39	20	75		Gravelly loam	1902	7	Apr. 23	Apr. 28		Apr. 1		June 28		June 28	
65	do.	39	20	75		do.	1903	8	Apr. 12	Apr. 22		do.		June 26		June 20	
67	do.	39	20	50	SE.	Sandy loam	1903	8	Apr. 9	Apr. 12	Apr. 6	Apr. 5		June 25	Oct. 26	July 5	
64	do.	39	25	225	SE.	Stony loam	1905	15	Apr. 21	Apr. 26	Apr. 19	Apr. 19	Aug. 25	July 6	Oct. 19	June 25	
64	do.	39	25	225	SE.	do.	1906	16	Apr. 26	Apr. 30	May 10	Apr. 28	Aug. 30		Oct. 11		
60	do.	39	35	75	SW.	Heavy loam	1902	10	May 1	May 4	May 28	Apr. 24	July 5	July 8	Nov. 15	July 8	
60	do.	39	35	75	SW.	do.	1903	11	Apr. 29	May 1	Apr. 20	Apr. 6			Nov. -		
60	do.	39	35	75	SW.	do.	1904	12	May 7	May 8	May 11	Apr. 30	June 30	July 25	Sept. 17		
79	New Jersey	39	35	90	NW.	Gravelly loam	1902		Apr. 24	Apr. 28	Apr. 15	Apr. 20		July 6	Nov. 15	July 6	
59	do.	39	40	300		Clay loam	1902	10	Apr. 26	do.	do.	Apr. 15	July 1	July 15		July 1	
91	do.	39	50					5	Apr. 30	May 1		Apr. 14	July 20	July 20		July 10	
82	do.	39	55	50	W.	Sandy loam	1902	6	Apr. 27	May 3				July 15		do.	
84	do.	39	55	50	N.	Heavy loam	1902	25	Apr. 25	Apr. 30	Apr. 16	Apr. 20	Aug. 1	July 10	Oct. 10	July 20	
84	do.	39	55	50	N.	do.	1903	26	Apr. 18	Apr. 25	May 2	Apr. 1	July 25	July 15	Oct. -	July 15	
84	do.	39	55	50	N.	do.	1904	27	May 5	May 9		Apr. 25	July 10	July 4		July 4	
86	do.	40	0	50	NW.	Loam	1904	20	do.	May 7		do.	July 15	July 1	Sept. 22	July 5	
86	do.	40	0	50	NW.	do.	1905	21	Apr. 29	May 4		May 8	July 1	July 15	Nov. -	July 1	
80	do.	40	5	60	N.	Gravelly loam	1904		May 4	May 7	Apr. 24		June 1	Aug. 1	Oct. 10	July 10	
80	do.	40	5	60	N.	do.	1906	9			Apr. 6	Apr. 23	June 7	July 25		July 8	
80	do.	40	5	60	N.	do.	1907	12	May 5		Apr. 20	Apr. 8	June 28	July 15		July 6	
81	do.	40	10	75	None.	Heavy loam	1907	16	May 3	May 8		Apr. 24		July 23	Oct. 21	July 13	
95	do.	40	10	40	N.	Sandy loam	1904	10	May 7	May 10				July 11	Sept. 22	July 4	
98	do.	40	30	600	S.	Red shale	1905	14	May 1	May 7	Apr. 16	Apr. 29		July -	Oct. -		
99	do.	40	35	40	NW.	Sandy loam	1907	10	May 10		May 12	May 4			Oct. 5		
88	do.	40	50	500	E.	do.	1907	10	May 8	May 12	Apr. 25	May 14		Aug. 1	Oct. 10	Aug. 1	
104	do.	41	0	600	None.	Clay loam	1905	3	May 6	May 10	Apr. 24	Apr. 26	July 5	Aug. 12	Oct. 22	Aug. 12	
104	do.	41	0	600	None.	do.	1906	4	May 9	May 14	May 11	do.	July 4	July 25	Oct. 12	Aug. 1	
104	do.	41	0	600	None.	do.	1907	5	May 15	May 20	May 12	Apr. 29	July 7	Aug. 6	Oct. 25	Aug. 19	
101	do.	41	10	550	SE.	Gravelly loam	1904	11	May 6	May 15	Apr. 23	Apr. 28			Sept. 22		
103	do.	41	15	400	SW.	Sandy loam	1904		May 10	do.	May 5						

TABLE IV.—*Phenological records—Apples*—Continued.

YORK IMPERIAL. Synonym: *Johnson's Fine Winter.*

Observer's number.	State.	Approximate latitude. ° ′	Elevation (feet).	Slope.	Soil.	Year.	Age of tree (yrs.).	Date first bloom.	Date full bloom.	Date last spring frost.	Date leaf buds begin to open.	Date terminal buds begin to form.	Date picked (first picking).	Date first fall frost.	Date fit for use.	Keeps until—
11	North Carolina	35 25	1,990	SE.	Porous loam	1904	20	Apr. 30	May 5	Apr. 21	May 10	June 15	Sept. 15	Oct. 24	Oct. 20	Nov.
10	do	35 30	2,875	SW.	Clay loam	1903	7	Apr. 6	Apr. 16	Apr. 28	Apr. 4	July 15	Oct. 28	Oct. 25	Dec. 10	Feb.
10	do	35 30	2,875	SW.	do	1904	8	Apr. 15	Apr. 28	Apr. 26	Mar. 25	July 4	Oct. 15	Oct. 16	Nov. -	Dec.
10	do	35 30	2,875	SW.	do	1905	9			Mar. 10	Mar. 28	July 10	Oct. 25		Nov. 20	Feb.
10b	do	35 30	3,500	SE.	Gravelly clay	1902	7	Apr. 22	Apr. 28	Apr. 15	Apr. 22	July 27	do	Oct. 5	Dec. 20	Do.
10d	do	35 30	4,500	SE.	Sandy loam	1902	12	May 1	May 6	Apr. 22		July 31	Oct. 20	Oct. 1	do	Mar.
10d	do	35 30	4,500	SE.	do	1903	14	May 5	May 18	Apr. 28	May 4	July 25	Oct. 15	Oct. 5	Dec. 1	Feb.
16	do	36 10	3,250	S.	Clay loam	1904	12	May 10	do	Apr. 21	Apr. 27	July 22	Oct. 10	Oct. 15	Dec. 15	Apr.
16	do	36 10	3,250	S.	do	1905	13	Apr. 20	May 1	May 16	Apr. 16	July 20	do	Oct. 20	do	Do.
47	Virginia	36 45	1,700	SE.	Black loam	1905		Apr. 15	do	May 1			Oct. 1		Nov. 20	Do.
33	do	37 0	5	None.	Sandy loam	1904	8	Apr. 23	Apr. 30	Apr. 20	Apr. 4	June 23	Sept. 5	Oct. 17	Oct. 10	Nov.
49	do	37 5				1907	11	Apr. 26	May 7	do	May 5		Oct. 6	Oct. 15	Sept. 25	Apr.
40	do	37 10	2,400	None.	Clay loam	1907	8	Apr. 12	Apr. 30	Apr. 8						
39	do	37 10	2,000	NW.	Dark loam	1902	10	Apr. 26	May 1	Apr. 18	Apr. 20		Oct. 10	Sept. 10	Jan. 20	Apr.
46	do	37 15	500	S.	Sandy loam	1903	16	Apr. 2	Apr. 6						Oct. 1	Mar.
38	do	37 15	2,170	NW.	Limestone clay	1902	13	Apr. 28	May 3	Apr. 18	Apr. 11		Sept. 25	Sept. 14		
24	do	37 20	1,000	S.	Red clay	1903				Apr. 5			Oct. 30	Oct. 30		
25	do	37 20	1,000	SE.	do	1905	18	Apr. 25	May 5	Apr. 15	Apr. 25	July 20	Oct. 20	Oct. 20	Nov. 15	Apr.
31	do	37 25	1,400	NW.	Gravelly loam	1902	6	Apr. 21	Apr. 24	Apr. 8	Apr. 21	July -	Sept. 25		do	
44	do	37 45	630	SW.	Loam	1904	12	Apr. 24		Apr. -	Apr. 10	June 15				
42	do	37 45	800	SE.	Clay loam	1903	20	Mar. 24	Apr. 15	Apr. 15	Apr. 25		Sept. 15		Dec. 15	June.
45	do	37 50				1906	20		Apr. 22	May 9				Oct. 10		
50	do	37 55	200	E.&W.	Sandy loam	1903	16	Mar. 30	Apr. 4		Apr. 5		Oct. -		Oct. 20	Mar.
50	do	37 55	200	E.&W.	do	1904	17	Apr. 20	Apr. 25	Apr. 6	Apr. 25		Nov. 1	Sept. 7		
50	do	37 55	200	E.&W.	do	1905	18	Apr. 10	Apr. 15	Apr. 19	Apr. 15		Oct. 1	Oct. 22	Oct. 1	Dec.
50	do	37 55	200	E.&W.	do	1906	19	Apr. 15	Apr. 25	May 11	Apr. 25		Oct. 20		Oct. 30	Do.
41	do	38 0	1,200	N.	Black loam	1903	19			Apr. 5	Mar. 26		Oct. 2	Oct. 15	Jan. 15	Mar.
19	do	38 5	900	S.	Red clay	1905	18	Apr. 15	Apr. 23	Apr. 19	Apr. 1		Sept. 1	Oct. 7	Sept. 1	
22	do	38 10	1,200	NE.	Gravelly loam	1907	20	Apr. 20	do	May 22	Mar. 29		Oct. 15	Oct. 9	Jan. 15	Mar.
23	do	38 10	1,400	NE.	do	1907	9	Apr. 23	May 1	May 18	Apr. 1	July 20	Oct. 8	Oct. 13	Dec. -	May.
53	do	38 25	1,400	W.	do	1902	16	Apr. 26	do		Apr. 15		Oct. 1			
53	do	38 25	1,400	W.	do	1903	17	Apr. 13	Apr. 22		Apr. 10		Oct. -		Dec. -	Feb.
53	do	38 25	1,400	W.	do	1905	19	Apr. 20	Apr. 28	Apr. 24	Apr. 11		Oct. -	Oct. -	Oct. -	Do.
53	do	38 25	1,400	W.	do	1906	20	Apr. 25	May 1	May 11	Apr. 15		Sept. 25			
35	do	38 30	400	NE.	Red clay	1902	15	Apr. 24	Apr. 27	Apr. 15	do	Aug. 20	Oct. 15	Oct. 22	Oct. 1	Apr.
35	do	38 30	400	NE.	do	1903	16	Apr. 12	Apr. 22	Apr. 5	Apr. 2	Aug. 4	Oct. 1	Oct. 18		Do.
35	do	38 30	400	NE.	do	1904	17	Apr. 30	May 6	Apr. 23	Apr. 8	July 29	Sept. 26	Sept. 23	Sept. 1	Do.

[illegible]	....do.	[illegible]	[illegible]	[illegible]	[illegible]	....do.	[illegible]	18	Apr. [illegible]	Apr. [illegible]	[illegible]	Apr. 11	July 20	....	Oct. 11	....	May.
[illegible]	....do.	38	45	375	SE.	Porous loam	1906	19	Apr. 25	Apr. 22	May 11	Apr. 15	July 1	Sept. 15	Oct. 25	....	Do.
[illegible]	....do.	38	45	375	SE.	....do.	1902	15	Apr. 8	Apr. 12	Apr. 5	Apr. 30	....	....	Oct. 11	....	Mar.
[illegible]	....do.	39	0	600	......	Sandy loam	1900	33	Apr. 27	Apr. 29	May 11	[illegible]	....	....	....	....	....
[illegible]	....do.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1907	14	May 1	May 9	May 9	Apr. 15	....	Oct. 10	Oct. 10	Feb. –	Apr.
55	....do.	39	0	1,000	NE.	Porous loam	1902	14	Apr. 24	Apr. 28	Apr. 14	Apr. 18	June 15	Sept. 25	....	Sept. 25	Late.
54	....do.	39	0	1,000	NE.	....do.	1903	15	Apr. 10	Apr. 22	Apr. 5	Apr. 2	June 10	Sept. 30	....	Dec. 1	June.
54	....do.	39	0	1,000	NE.	....do.	1904	16	May 4	May 10	Apr. 20	Apr. 27	...do.	...do.	....	Oct. –	May.
54	....do.	39	0	1,000	NE.	....do.	1905	17	Apr. 22	Apr. 28	Apr. 19	Apr. 10	...do.	Oct. 1	....	....	....
54	....do.	39	0	1,000	NE.	....do.	1906	18	Apr. 25	May 1	May 8	Apr. 19	...do.	...do.	....	Oct. 1	Apr.
54	....do.	39	0	1,000	NE.	....do.	1907	19	Apr. 22	Apr. 27	Apr. 23	Apr. 3	June 15	...do.	....	Dec. –	June.
32	....do.	39	10	500	NW.	Clay loam	1905	11	Apr. 25	...do.	Apr. 18	Apr. 7	June 18	Oct. 4	....	Dec. 1	Mar.
32	....do.	39	10	500	NW.	....do.	1906	12	Apr. 30	May 4	Apr. 25	Apr. 20	June 15	....	Oct. 15	....	....
37	....do.	39	10	600	NW.	....do.	1903	17	Apr. 20	Apr. 25	....	....	....	....	....	....	....
72	Delaware	39	10	70	None.	Sandy loam	1902	7	Apr. 24	Apr. 27	....	....	....	Oct. 30	Oct. 20	Dec. 1	Apr.
68	Maryland	39	10	550	S.	Clay loam	1906	9	Apr. 20	May 3	May 10	Apr. 19	....	Oct. 1	Oct. 12	Nov. 15	Jan.
65	....do.	39	20	75	......	Gravelly loam	1902	6	Apr. 26	Apr. 29	....	Apr. 9	....	....	....	....	....
65	....do.	39	20	75	......	....do.	1903	7	Apr. 20	....	....	Apr. 2	....	....	....	....	....
64	....do.	39	25	225	S.	Porous loam	1907	7	May 5	May 10	May 5	May 1	....	....	Oct. 17	....	....
63	....do.	39	30	150	N.	Clay loam	1907	20	May 1	May 6	May 12	Apr. 24	Aug. 6	Oct. 14	Oct. 15	....	Apr.
58	....do.	39	35	300	S.	Limestone loam	1906	20	...do.	May 5	May 10	Apr. 25	....	Oct. 1	Oct. 12	Nov. 1	May.
58	....do.	39	35	300	S.	....do.	1907	21	May 4	May 9	May 12	Apr. 28	....	Oct. 25	Oct. 15	...do.	Do.
62	....do.	39	35	500	E.	Loam	1905	40	Apr. 28	May 6	....	....	....	Oct. 10	....	Dec. 1	Do.
60	....do.	39	35	75	SW.	Heavy loam	1902	15	Apr. 27	May 2	May 28	Apr. 23	July 10	Oct. 5	Nov. 15	Sept. 1	Late.
60	....do.	39	35	75	SW.	....do.	1903	16	Apr. 29	...do.	Apr. 20	Apr. 6	July 20	....	Nov. –	....	....
60	....do.	39	35	75	SW.	....do.	1904	17	May 9	May 12	May 11	Apr. 30	June 30	Oct. 5	Sept. 17	....	Late.
60a	....do.	39	35	125	SW.	Sandy loam	1902	35	Apr. 26	Apr. 28	Apr. 20	Apr. 22	July 12	Sept. 12	Nov. 15	Sept. 1	Do.
60a	....do.	39	35	125	SW.	....do.	1903	36	Apr. 23	...do.	...do.	Apr. 24	July 9	Oct. 3	Nov. –	....	Mar.
60a	....do.	39	35	125	SW.	....do.	1904	37	May 2	May 9	Apr. 21	Apr. 29	July 5	Oct. 8	Sept. 17	....	Late.
90	New Jersey	39	45	125	SW.	Gravelly loam	1907	10	May 4	May 10	...do.	....	....	....	....	....	....
82	....do.	39	55	50	W.	Sandy loam	1902	6	Apr. 25	May 2	....	....	....	Sept. 20	....	Sept. 20	Dec.
84	....do.	39	55	50	N.	Heavy loam	1902	35	Apr. 27	May 1	Apr. 16	Apr. 20	Sept. 15	Oct. 1	Oct. 10	Nov. 20	Apr.
84	....do.	39	55	50	N.	....do.	1904	37	May 7	May 11	....	Apr. 27	Aug. 10	...do.	....	Dec. 1	Mar.
86	....do.	40	0	50	NW.	Loam	1904	20	May 5	May 8	....	Apr. 28	July 25	...do.	Sept. 22	Oct. –	Late.
81	....do.	40	10	75	None.	Heavy loam	1907	12	...do.	May 11	....	Apr. 25	....	Oct. 7	Oct. 21	....	Do.
96	....do.	40	15	90	N.& S.	Clay loam	1904	10	May 10	May 16	....	May 7	....	Oct. 10	Sept. 17	Oct. 10	....
96	....do.	40	15	90	N.& S.	....do.	1905	11	May 4	May 10	....	Apr. 25	....	Oct. 13	Oct. 18	Feb. –	Mar.
94	....do.	40	20	140	S.	Sandy loam	1903	37	Apr. 28	May 1	May –	Apr. 9	June 13	Oct. 10	Oct. –	Oct. –	Do.
94	....do.	40	20	140	S.	....do.	1904	38	May 6	May 11	....	Apr. 30	July 16	Oct. 1	Sept. 20	...do.	Do.
98	....do.	40	30	600	S.	Red shale	1905	14	....	May 8	Apr. 16	Apr. 26	....	Sept. –	Oct. –	....	Do.
99	....do.	40	35	40	NW.	Sandy loam	1907	12	May 9	....	May 12	May 1	Sept. 15	Oct. 15	Oct. 5	Oct. –	Apr.

PLATES.

DESCRIPTION OF PLATES.

PLATE I. (*Frontispiece.*) A well-kept Yellow Transparent orchard about 10 years old. Good cultivation has been given and the trees have made an excellent growth.

PLATE II. Wagons and packages used in handling summer apples. Fig. 1.—Wagon loaded with half-bushel baskets of summer apples for the Philadelphia market. This load consists of 149 baskets. The wagon is a common type used in New Jersey in the vicinity of Philadelphia for hauling apples, tomatoes, and other truck to market. Fig. 2.—Wagon loaded with seventy-three ⅞-bushel baskets of summer apples ready for hauling to the railroad station. The wagon is a common type used in Delaware for this purpose. The manner of loading the baskets on the wagon is also shown.

PLATE III. Packing-house views. Fig. 1.—Exterior view of a packing house in Delaware. There are four doors, one on either side. Each door is numbered to facilitate in giving directions in regard to receiving and discharging fruit. A truck used in hauling fruit from the orchard to the packing house is also shown. Fig. 2.—Interior view of a packing house in Delaware showing a common method of handling the fruit in grading and packing summer apples. Covers are attached to the baskets before they leave the packing house.

PLATE IV. Typical summer-apple orchards. Fig. 1.—A Maiden Blush orchard in New Jersey, about 30 years old. The props under the trees are suggestive of the productiveness of this variety in this section. The orchard receives thorough cultivation and spraying. Fig. 2.—A Red Astrachan orchard in Delaware, about 25 years old. It has been well maintained. The trees are 36 feet apart. The branches nearly interlock in both directions.

FIG. 1.—WAGON LOADED WITH HALF-BUSHEL BASKETS OF SUMMER APPLES GROWN IN NEW JERSEY FOR THE PHILADELPHIA MARKET.

FIG. 2.—WAGON LOADED WITH SEVEN-EIGHTHS-BUSHEL BASKETS OF SUMMER APPLES GROWN IN DELAWARE, READY TO BE HAULED TO THE SHIPPING STATION.

WAGON AND PACKAGES USED IN HANDLING SUMMER APPLES.

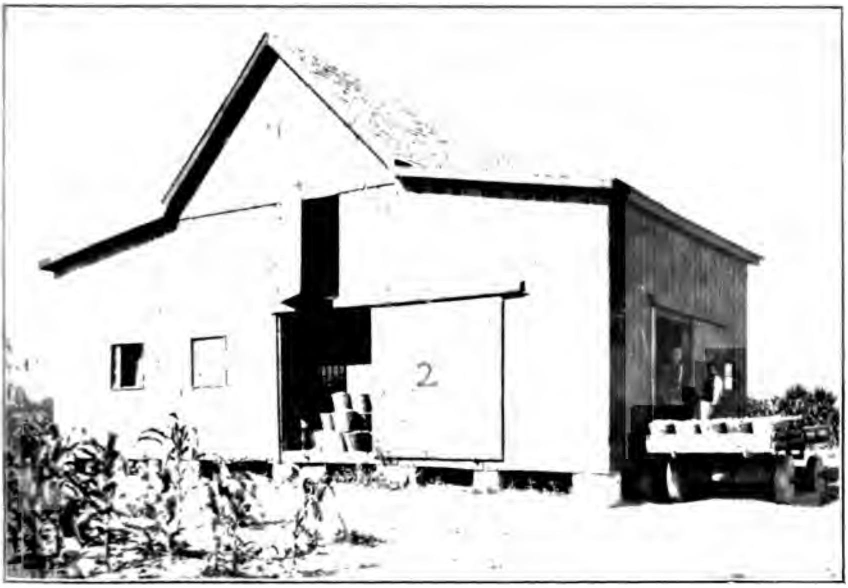

FIG. 1.—EXTERIOR VIEW OF A PACKING HOUSE.

FIG. 2.—INTERIOR VIEW OF A PACKING HOUSE, SHOWING A COMMON METHOD OF HANDLING THE FRUIT IN GRADING AND PACKING SUMMER APPLES.

PACKING-HOUSE VIEWS IN DELAWARE.

FIG. 1.—A MAIDEN BLUSH ORCHARD IN NEW JERSEY, ABOUT 30 YEARS OLD.

FIG. 2.—A RED ASTRACHAN ORCHARD IN DELAWARE, ABOUT 25 YEARS OLD.

TYPICAL SUMMER-APPLE ORCHARDS.

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[Synonyms of apples are distinguished from the leading varietal names by the use of italic type.]

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 195.

B. T. GALLOWAY, *Chief of Bureau.*

THE PRODUCTION OF VOLATILE OILS AND PERFUMERY PLANTS IN THE UNITED STATES.

BY

FRANK RABAK,

CHEMICAL BIOLOGIST, DRUG-PLANT, POISONOUS-PLANT, PHYSIOLOGICAL, AND FERMENTATION INVESTIGATIONS.

ISSUED DECEMBER 9, 1910.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1910.

BUREAU OF PLANT INDUSTRY.

Chief of Bureau, BEVERLY T. GALLOWAY.
Assistant Chief of Bureau, G. HAROLD POWELL.
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., August 26, 1910.

SIR: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 195 of the special series of this Bureau a manuscript by Mr. Frank Rabak, Chemical Biologist, entitled "The Production of Volatile Oils and Perfumery Plants in the United States," submitted by Dr. R. H. True, Physiologist in Charge of the Office of Drug-Plant, Poisonous-Plant, Physiological, and Fermentation Investigations.

There is a steady demand for information concerning plants yielding materials used in the manufacture of perfumery products; also concerning the processes and apparatus required to utilize these oil-bearing plants. This line of agricultural work has not yet reached any marked development outside of the peppermint industry in Michigan, New York, and Indiana, but the outlook for a further growth of this branch of special agriculture seems worth consideration. Much experimental work will be required to determine the most favorable locations for operation, and practical experience in handling the crops and the special apparatus needed in utilizing them must be accumulated. However, the economic significance of this class of products seems likely to justify the efforts required.

Respectfully,

G. H. POWELL,
Acting Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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ILLUSTRATIONS.

THE PRODUCTION OF VOLATILE OILS AND PERFUMERY PLANTS IN THE UNITED STATES.

INTRODUCTION.

The use of aromatics and perfumery dates back to the early ages when spices, balsams, asafetida, and other resinous exudations, many of which possess agreeable odors, were used for the purpose of scenting. The peculiar, agreeable aromas emanating from plants growing in their native habitats may be supposed to have early aroused the attention and admiration of the primitive peoples, although it may not have been known in what forms plants and flowers possessed their aromas. Before the art of distillation was known, the ancient peoples used the odoriferous plants and spices in their dried forms for their agreeable odors. Gradually, however, the development of special utensils for other domestic purposes may have resulted in the discovery of methods for the separation of odors from plants and plant products.

The use of distilling apparatus by the ancients in their endeavor to solve the problem of the transmutation of the elements and in other researches requiring the separation of volatile from nonvolatile substances antedates its use for the production of essential oils and perfumes, but it was probably learned at an early date that the odors present in plants and plant exudations were capable of separation because of their greater volatility when compared with the other constituents present. The first mention in ancient Greek writings of the separation of an odor from a crude substance is that of the oil of cedar, which was separated from the oleoresin by means of the crudest form of apparatus. This consisted of an open earthen kettle in which the oleoresin was boiled with water, the vapors of steam and oil being collected in layers of wool so placed that the steam from the kettle passed through the wool, which served as a condenser and retained the oil and water. Gradually this apparatus was transformed until it consisted of two definitely related parts, the kettle, or body of the still, and the removable head, which, besides closing the kettle, also acted as a condensing device on account of its exposure of a large surface to the air. Further improvements were made from

time to time, until the apparatus came to consist of a still body with a detachable head, to admit of the introduction of the material, and of a condensing worm or tube surrounded by flowing cold water. The highly efficient modern still embodies in a more elaborated adaptation the essential principles of this crude apparatus.

Along with the development of the necessary apparatus there have grown up in different parts of the world many large and small industries founded on volatile-oil production. From the small stills formerly used in making essences or spirits for use in the home for medicinal, condimental, or perfumery purposes from herbs gathered wild or grown in the garden, there have come the extensive perfumery industries of southeastern France, the attar-of-rose industry in Bulgaria, the peppermint and turpentine industries in the United States, and the other many and varied phases of the great industry of volatile-oil production.

The present centers of activity in this branch of manufacture have become established where they exist through a favorable combination of conditions, including the adaptation of soil and climatic conditions to the needs of the plants concerned and suitable labor conditions. In southwestern France a general perfumery industry of great importance, based on the production of lavender, cassie, rose, violet, and other perfumery plants, has grown up. The attar of roses from Bulgaria and Turkey, the rose-geranium oils from Algeria, Reunion, and other French colonies, the lavender and other essential oils from England, and the citrus oils from Italy, as well as the lemon-grass, citronella, vetiver, and other volatile-oil and perfume-producing products from India, may be mentioned as important industrial products. In the United States and in Japan the production of peppermint oil and its products constitutes an important industry. In many instances introduced plants are used; in others, native species, usually brought under cultivation, form the basis of production.

The growth of the volatile-oil industry has been most rapid in late years in Germany and France, due in part to the opening up of remunerative lines of work by pioneering scientific workers and in part to the greater demand for these products by the manufacturers of those countries. Although volatile oils find much use in a medicinal way, the greatest demands come from the makers of perfumeries and of flavors. As a result of scientific research along the lines of perfume chemistry, not only has a great field for commercial activity been discovered but scientific knowledge itself has been greatly enlarged. This mutually helpful relation between science and commerce has been conspicuously developed in France and Germany, but to only a relatively slight extent in this country. In view of the increasing importance of this class of products to American commerce, it seems

highly advisable that steps be taken to investigate the possibilities of our country in this direction. With our great range of latitude and variety of climate and soil, the conditions naturally favorable to the production of such oils and perfumes should be available. Other questions, such as labor and transportation facilities, must be considered. It is probable that by careful, scientific study of the situation the way may be opened for the development of somewhat extensive industries based on the growing and manufacturing in this country of volatile-oil products now either imported or neglected. These industries are already represented by the peppermint, spearmint, and wormwood products grown in New York, Michigan, Indiana, Wisconsin, and other States of the upper Mississippi Valley.

AROMA OF PLANTS.

NATURE OF ODORS.

Of the countless numbers of plants in the vegetable kingdom, a large percentage possesses peculiar aromatic odors, by means of which the plants may ofttimes be characterized. The substances which impart these peculiar odors to plants consist of mixtures of compounds oily in character and of a volatile nature; hence the designation "volatile oils."

It may be generally stated that all plants which in the growing condition give off a pronounced odor or which produce this odor when the leaves or flowers are rubbed between the fingers contain an essential oil. However, this must not be construed to mean that all volatile oils must necessarily be derived from plants which possess an odor, there being plants which do not possess the oil pre-formed in the tissues, but which through the interaction of constituents in the plant under proper conditions yield a volatile oil. A common example of this class of plants or plant products is the bitter almond, which yields the bitter-almond oil of commerce by maceration of the ground kernels with water, the oil formation taking place during maceration.

The aroma of plants is not necessarily due to volatile oils, there being other odor-bearing substances which, while distinctly aromatic, are not of an oily character. Reference is here made to plants and plant products which, while not possessing any odor during the growing period, develop very fragrant odors after harvesting and drying. An example of this class is the vanilla bean of commerce, which in a green condition is odorless but which when properly cured develops the characteristic fragrant vanilla odor. In this case, according to Lecomte,[a] a glucosidal body in the plant, coniferin, is

[a] Lecomte, Henri. Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences, vol. 133, 1901, p. 745.

hydrolized during the curing process by plant enzymes or fermen to the compound coniferyl alcohol, which in turn is oxidized b oxydase to vanillin. In this case a characteristic odor is perceptibl yet no volatile oil can be separated from the plant. A fuller di cussion of this class of substances will follow.

With only a few exceptions it may be stated that volatile oils e: ist in the tissues of a plant as minute globules, sometimes inclosed i cells but in some instances in enlarged cavities so conspicuous as to b seen without the aid of a lens or a microscope. By a careful e: amination of the leaf of a peppermint plant, especially at the time c blossoming, tiny glistening particles of oil are clearly discernibl The close scrutiny of the peel of a lemon or an orange discloses t view small, circular oil glands under the epidermis, imparting to i much of the characteristic roughened appearance. Such seeds a cloves, fennel, and anise contain oil passages directly below the epi dermis surrounding the endosperm or embryo of the seeds.

The volatile oils in plants do not represent simple substances bu are complex mixtures of numerous aromatic compounds which posses a definite chemical composition.* However complex the compositio of an oil may be, usually one constituent seems to impart the char acteristic odor and stands out conspicuously. Generally this con stituent attracts attention as the odor bearer of the plant or oil.

The substances which supply the aroma to plants or to essentia oils may be resolved by chemical classification into several groups o: organic compounds, namely, hydrocarbons, acids, alcohols, esters aldehydes, ketones, oxids, phenols, and sulphur compounds.

Volatile oils with but few exceptions contain constituents whicl belong to two or more of the above-mentioned groups of organic compounds. Although each of the groups may contribute to the complex odor of a plant or of a volatile oil, usually compounds exist in the oil which seem to the observer to be especially agreeable and fragrant. The bearers of these pleasant odors which are so apparent even in complex mixtures are for the most part either ester-like or alcoholic in character. It is not unusual, however, that aldehydes, ketones, or phenols play the rôle of odor bearers in a few oils or plants, as, for example, the principal odorous constituent of lemon oil, which is the aldehyde citral, while the pronounced odor of pennyroyal oil is chiefly due to the ketone pulegone. The strongly aromatic odor of thyme is attributed to the phenol called thymol, while sulphur compounds are largely responsible for the aroma of the mustard oils.

Thus it may be perceived that while esters and alcohols impart agreeableness to the majority of oils, there are exceptions, as already stated. Such oils as peppermint, lavender, wormwood, rose, geranium, ylang-ylang, orange flower, and numerous others owe their

fragrance to alcohol or ester compounds, or to both, since these compounds are usually found accompanying one another in the oils. Owing to their particularly agreeable fragrance, the esters and the alcohols form a class of the so-called desirable constituents.

Esters represent a group of constituents which are formed by the interaction of alcohols and plant acids (esterification), an ester resulting by the elimination of water in the reaction. Almost invariably these esters possess a pleasant odor and convey the characteristic mellowness and fragrance to many of the essential oils from plants. Indeed, a number of oils are valued according to the percentage of esters which they contain. The largest number of pleasant-smelling esters usually occur in oils as formates, acetates, or butyrates, the acetic-acid esters prevailing. The oil of lavender flowers, for instance, owes its agreeable aroma to the acetic-acid ester of the alcohol linalool or to linalyl acetate. The oil is valued according to the percentage of linalyl acetate which it contains, although the free alcohol linalool also exists in the oil. In this connection it may be mentioned that the ester menthyl acetate imparts fragrance to peppermint oil, menthol being also an important constituent in this case.

Another striking example of an ester compound as the odor bearer of an oil is the methyl ester of anthranilic acid, which carries the odor of orange flowers. Further examples are not necessary to emphasize the importance of esters and alcohols in determining the aromatic value of oils or plants.

In view of the fact that certain constituents may be classed as odor bearers, the desirability of these constituents in volatile oils being evident, attention should be given to the possibility of increasing this class of substances by proper conditions of climate and cultivation.

LOCALIZATION OF ODORS.

Volatile oils, although found in all parts of plants, are localized more or less generally in certain portions. The leaves, possibly on account of their extensive area, often carry a large proportion of oil. In many plants, indeed, the leaves serve as the chief source of the oil. Mention may be made here of the oils obtained from leaves of such plants as the eucalyptus, bay, wintergreen, pine, lemon grass, citronella, and ginger grass. On the other hand, in some plants the oil is obtained principally from other parts, the leaves possessing little or no odor, as in the oil-yielding roses.

The flowering tops of aromatic plants as a rule yield oils of rich aroma, excelling the oils produced from any other portion of the plant. The exquisite bouquet of such oils as rose, lavender, cassie, orange flower, and ylang-ylang is well known, all of these oils being obtained from the flowers or flowering tops.

The fruit oils occupy a position of no little importance, representing an industry by themselves. The principal oils from the citrus fruits are obtained from the lemon, sweet orange, bitter orange (petit grain), and bergamot. In all of the above fruits the essential oil is contained in the peel of the fruit from which it is obtained.

Many of the various seed oils are very important commercially, being employed largely as perfumes and medicinal agents. Among the seed oils derived from the order Umbelliferæ (parsnip family) which possess especial value may be mentioned caraway, anise, fennel, and coriander. Other seeds yielding oils of commercial import are cardamom, American wormseed, mustard, bitter almond, peach, and apricot seeds.

In addition to the above and playing an important rôle in volatile-oil production are the bark and wood oils, the former being represented by such oils as sassafras, canella, and cinnamon. The wood oils comprise such oils as sandalwood, copaiba, and cedar, while from the woods indirectly are obtained several essential oils of value, namely, oils from oleoresins, as turpentine, copaiba, elemi, California turpentine (*Pinus sabiniana*), and Oregon balsam oil.

There are comparatively few root oils, the chief examples being valerian, snakeroot, and sassafras oils.

The aerial portion of the plant serves possibly more extensively for the extraction of volatile oils than any other of the plant parts mentioned. Peppermint, spearmint, and wormwood, from which oils are now produced commercially in this country, are typical instances.

DEVELOPMENT OF AROMA.

The development of the aroma in a plant is conditioned by the interaction of several important factors. It is generally accepted that a close relationship exists between the growth of the plant and climatic factors, such as heat, light, and moisture, and it seems clear also that these conditions play an important part in the formation of the aroma and materially influence its quality. The effect of climate upon the quality of the aroma is clearly shown by the varying fragrance of the oils produced by plants of the same species when they are grown in sections having a wide diversity of climatic conditions. Continuous sunshine, which may be a factor in the development of fragrance in one plant, may possibly exert a reverse action upon another in which the formation of the chief odoriferous constituents is not directly favored by the action of light. Usually, however, sunshine is a favorable agent for the production of delicate aromas, while, on the other hand, cloudiness or darkness has a tendency to lower the production of aromatic substances by the plant.

An abundance of moisture is required for the growth of certain plants and also for the development of aroma. This is especially true of plants whose habitat may be aquatic or subaquatic; in this case dryness becomes a direct hindrance to growth and likewise lessens the activity of the metabolic processes taking place within the organism.

On the other hand, many plants are especial lovers of dryness, particularly such as inhabit the western arid tracts and deserts. These excessively dry regions are not devoid of plant life; neither are they wanting in plants possessing odors. The sages are excellent examples of sturdy growers on dry lands, and many are decidedly aromatic, producing oils of excellent quality.

In both of the above extreme cases, coupled with the dryness or moisture, an abundance of sunshine is usually conducive to the formation of volatile oils in plant organs.

A typical example may be mentioned in the case of lavender. This highly fragrant oil is derived from the plant *Lavandula vera*, which grows for the most part in France and England and is much influenced by such factors as soil, dryness, moisture, altitude, and sunshine. Oils which possess the highest percentage of the odor bearer, linalyl acetate, are usually produced from plants grown on mountain slopes.

Lamothe[a] states that the finest grades of lavender plants of the Dromé region are grown at the highest altitudes (2,500 feet) in the mountain districts. Plants grown on the lowlands of these mountains have been found to be decidedly inferior. Most light soils are well suited to the growth of lavender, but those of a heavy or soggy nature should be avoided.

The lavender produced in the Mitcham district of England is generally considered to have the most agreeable fragrance. In England the conditions are decidedly different from those occurring in France, both with respect to soil and altitude. A chalky soil seems to be best adapted to the growth of lavender in the Mitcham district. The plant is, however, also grown profitably in the vicinity of Bournemouth, Dorsetshire, where the soil consists of sand and clay, with more or less peaty humus.[b] Fungous growths, it is stated, harm lavender where the drainage is not perfect. An abundance of humidity and sunshine is also considered necessary by the English growers.

Although it is generally conceded that the English lavender oil is the most fragrant, this property is attributed by Gildemeister, Hoffmann, and Kremers[c] to the invariably low ester content of the oil,

[a] Lamothe, M. L. Bul. Roure-Bertrand Fils., October, 1908, p. 33.

[b] Pharmaceutical Journal, vol. 83, 1909, p. 532.

[c] Gildemeister, Eduard, Hoffmann, Friedrich, and Kremers, Edward. The Volatile Oils, p. 606.

and their findings are further substantiated by Kebler[a] and by Parry.[b]

In the United States the cultivation of lavender has not advanced to any extent. However, in view of the fact that certain regions of the United States possess climate, soil, and other factors practically similar to those of the lavender-producing regions of France and of England, it does not necessarily follow that lavender may not be grown profitably in America.

The nature of the soil through its physical and chemical properties offers an important variable condition likely to affect the metabolism of the plant, and consequently the constituents elaborated by it. Experiments upon peppermint by Charabot and Hebert[c] seem to indicate that soils supplied with commercial fertilizers produce plants yielding oils superior in esters or odor-bearing compounds, the esterification of menthol in the plant seeming to be favored. Peppermint grown by the writer upon a soil rich in organic matter, a black loam, produced an oil noticeably richer in menthyl acetate than peppermint grown upon a clay loam. The existing conditions of climate were possibly also instrumental in bringing about this result.

Seasonal changes have also a marked effect not only upon the quality but also upon the quantity of oil produced by a plant. A plant distilled at its flowering period during one season may produce a certain yield of oil of certain quality, and in the following season, which may be entirely different, it may produce a much higher or lower yield of oil either superior or inferior in quality.

The agents already enumerated are instrumental in bringing about certain chemical changes in the composition of the oil in the cells or tissues of the living plants which contain the oil already formed. There is, however, another group of plants which, though not possessing the oil already formed in the plant tissues, do possess certain basal constituents from which the volatile oil is formed. These constituents usually belong to a class of plant constituents known as glucosids, which break down by hydrolysis into a sugar, generally glucose, and some other compound. The "other compound" which is formed by this hydrolysis in the case of some glucosids is volatile and constitutes the volatile oil from the plant.

Very common examples of plants with glucosidal bodies which yield a volatile oil are wintergreen and sweet birch. The leaves of the wintergreen and bark of the sweet birch contain the glucosid gaultherin, which under proper conditions of hydrolysis yields methyl salicylate and glucose. Methyl salicylate in this instance

[a] Kebler, L. F. American Journal of Pharmacy, 1900, p. 223.

[b] Parry, E. L. Chemist and Druggist, 1902, p. 168.

[c] Charabot, A., and Hebert, A. Bulletin du Jardin Colonial, vol. 27, 1902, 3d ser., pp. 224 and 914.

represents the volatile oil of wintergreen. In order to effect this hydrolysis of the glucosid in wintergreen or sweet birch, the material is simply macerated with water. A reaction immediately begins, assisted by the plant ferments, which act as catalysing agents, with the formation of the volatile methyl salicylate and glucose, as follows:

$$\underset{\text{gaultherin}}{C_{14}H_{18}O_8} + H_2O = \underset{\text{methyl salicylate}}{C_6H_4(OH)COOCH_3} + \underset{\text{glucose}}{C_6H_{12}O_6}.$$

If after the reaction is complete the fermented material is put into a distilling apparatus, the volatile oil of wintergreen and sweet birch may be distilled as a colorless oil with the characteristic wintergreen odor so commonly known.

In addition to the two plants mentioned containing glucosidal substances which split up into a volatile oil and a sugar, the ordinary bitter almonds and peach, apricot, and prune kernels may be mentioned. These kernels contain the glucosid amygdalin, which when hydrolyzed yields benzaldehyde, hydrocyanic acid, and glucose, as follows:

$$\underset{\text{amygdalin}}{C_{20}H_{27}NO_{11}} + 2H_2O = \underset{\substack{\text{hydro-}\\\text{cyanic}\\\text{acid}}}{HCN} + \underset{\substack{\text{benzalde-}\\\text{hyde}}}{C_6H_5CHO} + \underset{\text{glucose}}{C_6H_{12}O_6}.$$

Therefore, when the ground kernels are macerated or hydrolyzed in the presence of water and then distilled, the ordinary volatile oil characteristic of bitter almonds and of peach, prune, and apricot kernels, is obtained.

These kernel oils are in every way identical, just as the oils of wintergreen and sweet birch are practically identical, the former consisting chiefly of hydrocyanic acid and benzaldehyde and the two latter of nearly pure methyl salicylate.

One other example of an oil produced by fermentation is the oil of mustard seeds. These seeds contain the glucosid sinigrin, which likewise suffers hydrolysis when ground seeds are macerated in water, producing the volatile oil of mustard (allyl iso-sulphocyanid), glucose, and potassium acid sulphate, according to the following reaction:

$$\underset{\text{sinigrin}}{C_{10}H_{16}NS_2KO_9} + H_2O = \underset{\substack{\text{allyl iso-}\\\text{sulpho-}\\\text{cyanid}}}{C_3H_5CSN} + \underset{\text{glucose}}{C_6H_{12}O_6} + \underset{\substack{\text{potas-}\\\text{sium}\\\text{acid}\\\text{sulphate}}}{KHSO_4}.$$

The fermented mixture readily yields the volatile oil by distillation with steam. The medicinal action attributed to mustard seeds is due to the mustard oil developed in the reaction mentioned. This

oil, however, is not formed until the mustard is brought in contact with water, thus enabling the vegetable ferment to hydrolyse the glucosid, with the results specified.

These instances are cited here simply to make clear the fact that not all volatile oils preexist in plants and that some of our most valuable oils are obtained from plants entirely devoid of odor, which, however, develops when the proper conditions are supplied. The number of these special cases is comparatively few when we consider the vast number of plants which contain volatile oils existing as such in their tissues and depending for their development in the plant only on conditions of growth and nourishment.

EXTRACTION OF AROMA.

For the separation of the aromatic principle from a plant, several methods are in vogue, depending for their efficiency and practicability largely upon the nature of the odors to be extracted. The properties of the various odorous substances are such that in order to separate them in their entirety only such methods can be applied as will bring about the least possible change in the fragrant constituents. Because of the facility with which certain aromatic principles undergo change it is necessary at times to extract the perfume without exposing the materials to high temperatures and to other conditions which would tend to change their chemical nature. For this reason several methods are employed at the present time for the extraction of volatile oils and perfumes, each of which possesses advantages and disadvantages.

The following general methods find application in commerce for the separation of the odoriferous principles from plants and plant products: (1) Solution, (2) expression, and (3) distillation.

SEPARATION OF PERFUMES BY SOLUTION.

The method of solution as applied in practice is subdivided into three modifications, viz, by volatile solvents, by liquid fats, and by solid fats.

EXTRACTION WITH VOLATILE SOLVENTS.

The method of extraction with volatile solvents, such as ether, chloroform, benzene, petroleum ether, acetone, etc., is adaptable only to flowers, because of the comparatively small quantity of other kinds of extractive matter soluble in any one of these solvents. The method would be very impractical for the extraction of perfumes or oils from a whole plant or from the leaves of a plant, since whole plants or plant parts other than flowers contain considerable other matter besides the essential oil soluble in these solvents.

The method employed commercially for the extraction of odors by means of these volatile solvents embodies a process known as continuous extraction. By this method the solvent, after percolating through flowers and carrying with it in solution the odorous constituents, is heated in a proper receiving vessel and the vapors condensed and utilized further for extracting any remaining odor. The advantage of this method is the small amount of solvent necessary for extraction and the continual percolation of fresh solvent through the material.

The accompanying illustration (fig. 1) represents an apparatus used for this purpose, which consists chiefly of the percolator, the receiving vessel, and the condenser.

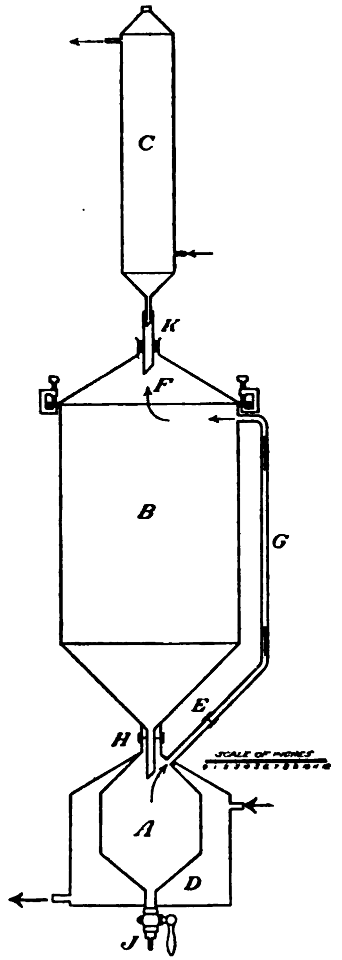

FIG. 1.—Continuous extraction apparatus. *A*, Receiving vessel; *B*, percolator; *C*, condenser; *D*, bath; *E*, union; *F*, cover; *G*, tube; *H*, union; *J*, drain cock; *K*, glass tube.

The percolator, *B*, in the bottom of which is placed a circular screen, is charged with the flowers to be extracted, and the removable cover, *F*, is attached by means of clamps, as indicated. A heavy gasket of cotton wicking or asbestos (previously moistened) or rubber is placed between the cover and the percolator to insure a tight connection. To the bottom of the percolator at *H* is attached the receiving vessel, *A*, and the hot water steam bath, *D*, by means of a screw union. Into the cover, *F*, is fitted a perforated rubber cork, through which passes a glass tube, *K*. The glass tube, *K*, is further connected with the condenser, *C*, by means of a perforated rubber stopper. The condenser may be of the single-tube or worm variety, the former being preferable. The tube *K* is of glass for the purpose of enabling the operator to observe the rapidity with which the condensation of vapors is taking place. After pouring the solvent through the condenser and into the percolator, heat (preferably steam or hot water) is applied to the bath, *D*. The steam is passed through the bath, *D*, in the direction indicated by the arrows. The solvent which has percolated through the flowers in *B* is

vaporized and driven up through the tube G (which should be covered with asbestos to prevent radiation) and into the percolator, thence into the condenser, where the vapors are condensed and drop back into the material. A continuous extraction is thus obtained with a minimum quantity of solvent.

For the final recovery of the solvent from A, the apparatus, after cooling, is disconnected at H and a screw cap attached to the neck of A. The tube G is disconnected at the union E, which may be connected with the condenser in proper position, and heat applied to D. The excess of the solvent is completely recovered in this manner, the resultant oil or perfume being drained off by opening the cock, J.

The chief disadvantage of an apparatus of this type is its narrow field of usefulness, which is practically restricted to the separation of perfume from flowers. When this apparatus is used for the extraction of other parts of the plant which may contain aromatic substances, the oil is liable to be contaminated by resins, waxes, etc., which would be extracted with the perfume by the solvent used. In order to purify further the crude oil obtained, steam distillation must be resorted to, in which case the delicate quality of the perfume obtained by the cold extraction would probably suffer slight changes induced by the steam.

EXTRACTION WITH LIQUID FATS.

The process of extraction with liquid fats is comparatively simple and depends upon the ability of a liquid, fatty oil to absorb the odors from flowers. For this purpose olive oil, lard, or other bland fixed oils may be advantageously used. The oil is placed in a kettle or vat (preferably porcelain lined) and heated to a temperature of 40° to 60° C.; the flowers to be extracted are then introduced either directly into the fatty oil or inclosed in coarse bags and suspended in the fat. The material is maintained at this temperature for a time varying from one-fourth to one and one-half days, when the mixture is either drained to remove the flowers or the bags are removed and expressed and recharged with fresh material. In this manner a perfumed oil is produced from which the perfume may be extracted by shaking out with strong alcohol, in which the odor is soluble and the fat insoluble. The fatty oil, which still retains traces of the flowery fragrance, may be used for further extraction of the same flowers.

This method of maceration in liquid, fatty oil is carried on to some extent in the perfume gardens of southern France and Germany, where perfumed oils are largely manufactured from such flowers as rose, jasmine, violet, tuberose, cassie, etc.

The extraction by maceration is advantageous because of its ease of operation and manipulation, but owing to the fact that heat is

necessary for the rapid absorption of the perfume, another method in which the fat is used as a cold absorbing medium has been devised and used.

EXTRACTION WITH SOLID FATS.

The process of absorption of perfumes in cold by means of fats, the "enfleurage" process, has long been used for the extraction of the more delicate odors, and is possibly more universally used than any other process for the preparation of certain flower odors.

The great avidity with which some solid fats absorb aromatic substances is the basis of the method. Odors of nearly every description are absorbed by neutral solid fats when the latter are placed adjacent to or in contact with the odoriferous substances.

The enfleurage process, which is based upon this peculiar property of fats, was originally carried out by spreading freshly picked flowers upon a thin layer of lard spread upon glass plates, the flowers being allowed to remain in contact with the lard until exhausted, when the apparatus was charged with fresh flowers. In this manner a perfumed pomade was produced containing the natural odor of the flowers.

For effecting a separation of the perfume from the solid fat, which is desirable in some cases, advantage is taken of the comparative insolubility of the fat in strong alcohol and the ready solubility of the perfume. Therefore, in preparing the pure perfume, the perfumed pomade is thoroughly and repeatedly agitated with alcohol, an alcoholic extract or perfumed essence resulting. This resulting extract is sometimes employed as such for producing delicate scents. In order to obtain the pure oil from the alcoholic extract, the alcohol is evaporated carefully in a vacuum, the concentrated oil or perfume of the flowers remaining. These concentrated oils, although often rather unpleasant in odor in extreme concentrations, produce an exquisite aroma when diluted.

The crude process of enfleurage just mentioned has been largely modified in recent years in order to promote rapidity of operation, to protect against loss of odor by nonabsorption, and to obviate the actual contact of the flowers with the lard. When the flowers are in actual contact with the lard there is a tendency toward the absorption of undesirable substances.

A practical apparatus of this nature (fig. 2) consists of a box, *H*, about 2 feet square and 6 feet high, so constructed as to be practically air-tight. In the lower portion of the box, which is supported about 2 feet above the floor, is placed a layer of sponges, *G*, or other porous material capable of holding moisture. The bottom of the sponge tray may be constructed of light copper gauze or brass gauze to permit the free access of air. Directly above are located the flower

trays, *A*, *B*, *C*, *D*, and *E*, which also have brass or tinned-iron screens of rather coarse mesh for bottoms. The sides, fronts, and backs of trays may be of wood. The trays may readily be placed in or taken out of the absorption box when refilling is necessary. Immediately above the flower trays are located a series of glass plates so constructed that they may be readily taken from the box and replaced. The absorbing medium, lard or other solid fat, is spread in a layer about one-half inch in thickness upon each glass plate, which is placed in its proper position. The front portion of the apparatus must be supplied with a tight-fitting door (not shown in the illustration) capable of being opened or removed to admit of charging and discharging the fat and flowers. When the flower trays have been charged with the freshly picked flowers and the door closed firmly a current of air is made to pass upward through the sponges and the flowers and the lard-laden tray, a more efficient circulation being produced by the alternating arrangement of glass plates. The odor-bearing air as it passes over the lard readily surrenders its perfume, which can be subsequently extracted from the lard. A small fan may be placed at the top of the apparatus or a blower at the bottom to produce the required movement of the perfume-laden air. The current should be regulated so that absorption is completely effected in its upward journey.

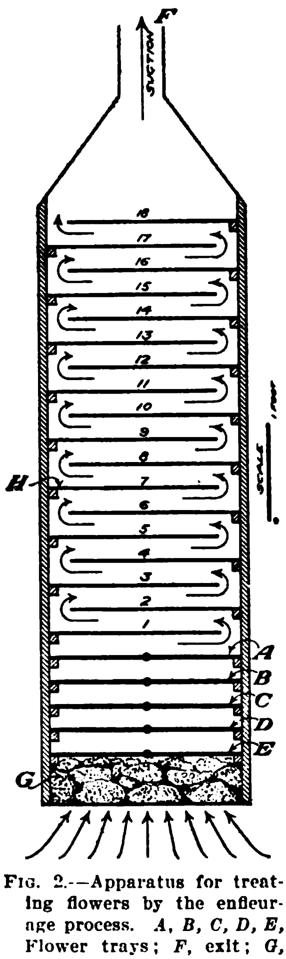

FIG. 2.—Apparatus for treating flowers by the enfleurage process. *A*, *B*, *C*, *D*, *E*, Flower trays; *F*, exit; *G*, sponge tray; *H* (1–18), glass plates.

When retained in fresh condition, flowers hold their aroma and even secrete perfume for a longer period of time than if allowed to wilt and dry; hence the moistened sponges in the bottom of the apparatus. Some flowers are even known to continue to secrete perfume if left in moistened air. The air drawn through the apparatus is moisture laden and therefore produces the best yield of perfume from the flowers.

The operation of the above contrivance may be continued with only such interruption as is required for recharging with fresh flowers when practically all odor has been drawn off. After the lard has been thoroughly charged, the perfume held in solution is

separated by a thorough agitation of the pomade with strong alcohol, preferably by means of a shaking or churning device in which the pomade is continually agitated and beaten in order to expose the largest surface possible to the solvent action of the alcohol. There results from this extraction operation an alcoholic extract of the flowers which possesses the natural odor to a very high degree. Because of the fact that no heat is necessary, the resulting extract is far superior to an extract prepared by the process of heating with liquid fats.

It is to be remembered, however, that the yield of perfume from some of the more delicate flowers, such as violet, cassie, tuberose, jasmine, etc., is rather small, which accounts largely for the exceedingly high prices of the extracts or pomades of these flowers.

Usually it is impossible to extract the odor from the pomade completely, even when extracted successively with fresh portions of alcohol. The fat after extraction still retains the characteristic aroma and may be used in this form or may be again spread upon the glass and utilized for further absorption from the same kind of flowers.

The amount of labor required for this work is necessarily large when the fact is taken into consideration that the flowers require hand picking. The time consumed by the entire process from the picking of the flowers to the finished extract is also very considerable. However, the quality and, consequently, the prices of these exquisite odors usually offset unfavorable conditions of labor and time in regions where this industry is carried on commercially.

SEPARATION OF PERFUMES BY EXPRESSION.

Another class of volatile-plant products already cited is so localized in the plant as to admit of the extraction of the oil by a different yet extremely simple process. The class of products referred to includes the citrus fruits, namely, the lemon, orange, bergamot, and other related fruits. Owing to the fact that the oil contained in these fruits is deposited in the outer portion of the peel and is therefore very accessible, the method of expression is peculiarly adapted to the citrus fruits and products.

There are several methods applicable to the extraction of the oil from the peel of the lemon, orange, and bergamot, all of which, however, embody the same principle, namely, the rupturing or breaking of the glands containing the oil and the collecting of the oil after it has been released.

In the method known as "écuelle à piquer," the rinds of the lemons are rubbed in hollow cups (écuelle, fig. 3) lined with sharp points, which lacerate the oil glands and allow the oil to exude.

This method has been largely displaced by the simple expression of the oil.

Owing to the ease with which the peels of the fruits liberate the oil, a method of expression is applied very conveniently to the separation of the oil. Usually the peels from half sections of the fruit are turned inside out and pressure brought to bear on the outer surface in such a manner as to rupture a large majority of the oil vessels. The oil thus liberated is collected upon a sponge, which absorbs it and from which it is subsequently squeezed. By this method, known as the "sponge method," the larger part of the oils of the lemon, the orange, and the bergamot is extracted, the operation being carried on usually at night, when other activities in the fruit work are at a standstill.

Expression by the sponge method is far from complete because of inability to bring pressure upon every portion of the peel; hence, after the "hand-pressed" oils, which are generally conceded to be the best grade, are obtained the peels are placed in a power press or in a crude still and the remaining oil is separated. This latter forms a secondary oil of commerce, generally considered to be much inferior to the sponged oil.

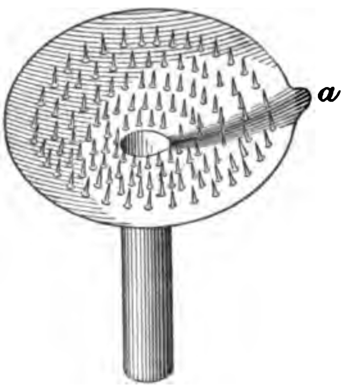

FIG. 3.—Écuelle for lacerating the oil vessels in the peels of oranges, lemons, etc. *a*, Draining lip.

The use of a mechanical device for rupturing lemons and bergamots and for expressing the oil from them has been introduced into some producing districts of Europe. However, only a small percentage of the oils is extracted in this way, the sponge system being most usually adopted.

Whether the process of steam distillation, which will be discussed later, if somewhat modified would produce a grade of oil equal to the hand-pressed oil is doubtful. At any rate, the oil containing only traces of compounds capable of decomposition at the usual temperature of steam, it should not be greatly inferior, production by this method would be easier, and its cost would be materially less.

SEPARATION OF PERFUMES BY STEAM DISTILLATION.

A simple still, which consists essentially of three parts, the still body, the condenser, and the receiver, with a suitable means of applying direct heat to the still body, containing material suspended in water, was used early in the eighteenth century. Even at the present time many smaller distillations are still carried on with this form of apparatus. The chief disadvantage of this type of still lies in the

fact that the heat, being applied directly, has a tendency to char or burn the materials adjacent to the bottom, and thus appreciably affect the quality of the aromatic product distilled over.

This method has been largely superseded in modern times by distillation with steam, the principles of which depend upon the property of the steam as it passes through the charged apparatus to carry with it the volatile portion of the plant in the form of vapors, which are condensed, together with the excess of watery vapor, and deposited in the receiving vessel. The three steps in the process are (1) the distilling, (2) the condensing of the vapors, and (3) the collecting of the oil. Even though the boiling points of the volatile oils separated by distillation from plants may be considerably higher than the temperature of steam, the odors are readily liberated by the passing steam and carried over.

APPARATUS.

The apparatus required for the three processes which collectively constitute steam distillation is of comparatively simple construction, consisting of (1) a still, (2) a still head (cover for body), (3) a condenser, and (4) a receiver.

The body of the still, or the receptacle in which is placed the material from which the oil is to be extracted, gives best results when cylindrical in form and may be constructed of various materials, preferably copper. However, some stills are made with wooden bodies. Galvanized iron heavily tinned on the interior is a suitable material, principally because of its cheapness and durability. The still may be constructed of any size desirable, provided the other parts, the condenser and the receiver, are in proportion, depending upon the amount of material to be used and the extent of production desired.

In figure 4, *A* represents the still, *B* the still head, or cover, *C* the condenser, and *D* the receiver. Through the side of the still at the point *E* passes a galvanized steam pipe from three-fourths to 1 inch in diameter, extending downward and finally terminating in the middle of the still, as shown by the dotted line. A spigot, *F*, is attached to the bottom of the still for draining the collected water from the apparatus. About 3 inches from the bottom of the still is placed a coarse screen, *H*, fastened to a wooden frame, which acts as a support for the herb or plant part to be distilled. Encircling the top of the still is an iron collar, which may be conveniently constructed of angle iron, to which the copper or the metal is securely attached.

The still head, or cover, *B*, is of the same material as the still and is slightly conical in shape, with an exit tube terminating in a union, at which point connection may be made with the condenser. Arour

the periphery of the cover is securely fastened a flat collar of iron of the same diameter as the angle iron used on the top of the still, so that with the cover in place the two will exactly coincide.

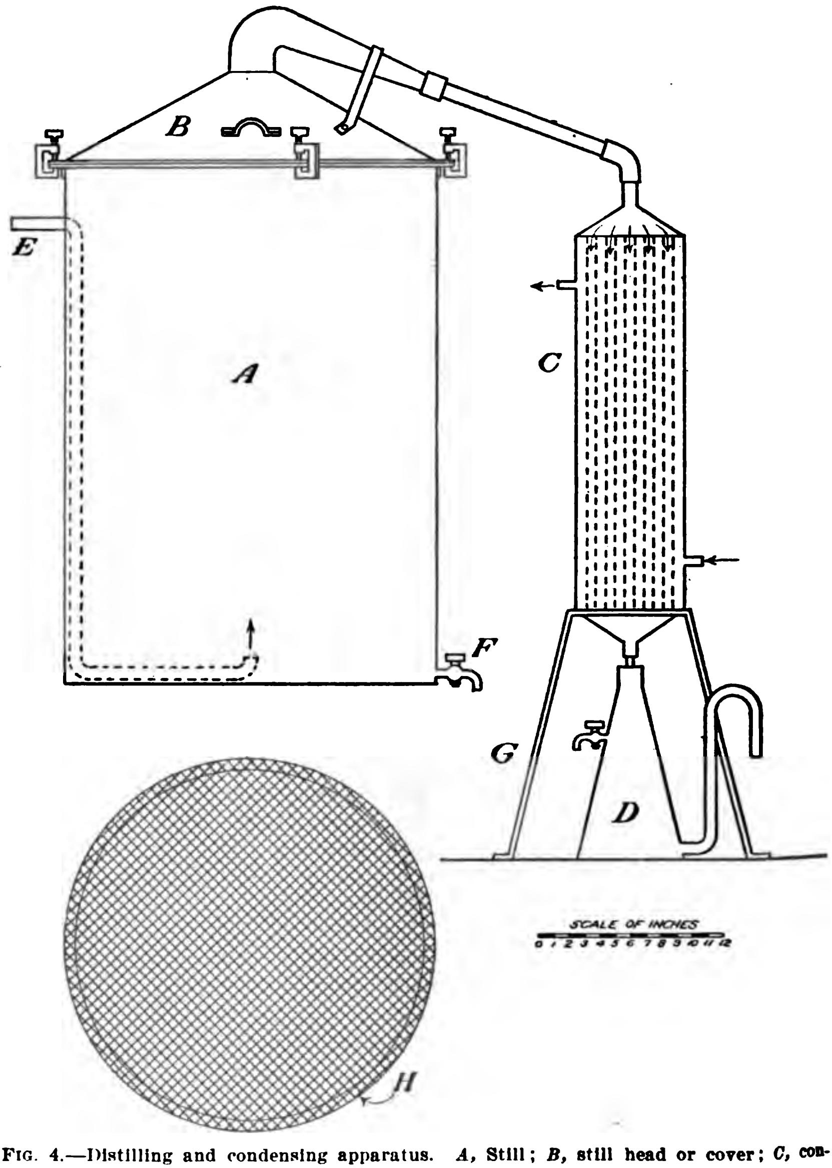

FIG. 4.—Distilling and condensing apparatus. *A*, Still; *B*, still head or cover; *C*, condenser; *D*, receiver; *E*, steam pipe; *F*, spigot; *G*, tripod; *H*, screen.

The condenser, *C*, as shown in figure 4, consists of a group of tubes (inside diameter one-half to 1 inch, depending upon the size of the condenser) surrounded by an outside jacket fitted with an inlet tube at the bottom and an outlet tube at the top, to enable cold

water to pass continually through the condenser in an upward direction. The condenser is attached to the still by means of the union joint, as illustrated.

The tripod, *G*, acts as a support for the condenser while the apparatus is in operation and also while the still is being charged or discharged. Under the bottom opening of the condenser is placed a receiver, *D*, of copper, with a goose-neck siphon tube extending from the bottom to within 2 inches of the top. On the side opposite the siphon tube is fastened a small brass spigot to admit the removal of the oil from time to time.

For the generation of steam, if a source is not otherwise available, a small boiler, such as is illustrated in figure 5, may be conveniently used. A small boiler, *A*, of light boiler iron fitted with about a dozen flues is capped by the cover, *B*. Other usual accessories are attached, viz, water gauge, *C*; pop valve, *D*; water gauge, *E*; and steam outlet, *F*. The boiler may be preferably set upon a gasoline stove or an open-fire stove or on a tripod with an open fire beneath. The pop valve may be set at about 8 to 10 pounds, no greater pressure being necessary. To replenish the water in the boiler a funnel tube attached to the pop valve may be used. Connection to the still is made most conveniently by the attachment of a short piece of rubber steam hose to *F*, as this admits a ready detachment from the still when distillation is completed. A pressure of 5 to 10 pounds of steam is sufficient for ordinary distillation. The size of the boiler may be slightly increased if distillation is to be conducted on a larger scale.

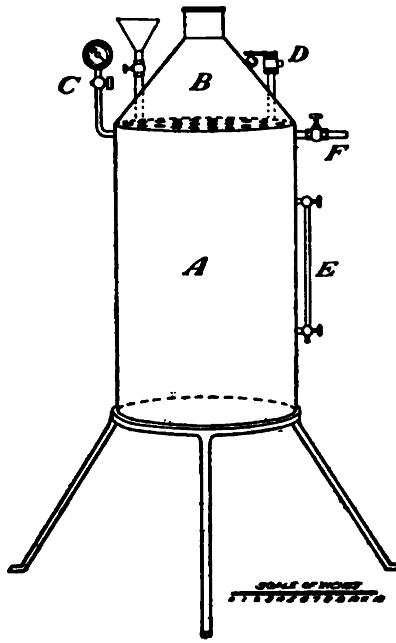

FIG. 5.—Steam generator. *A*, Boiler; *B*, cover; *C*, steam gauge; *D*, pop valve; *E*, water gauge; F, steam outlet.

The boiler just described possesses efficiency enough to distill charges of 75 to 150 pounds of herb.

For distillation on a commercial scale a large, stationary, upright boiler may be installed for the generation of steam, or, if convenient, steam may be taken from any high-pressure boiler which may be in use for other purposes. The volume necessary being very slight, indeed, is scarcely perceptible upon the steam gauge.

METHOD OF OPERATION.

To charge the still, place the false bottom in the still and pack the herb firmly until completely filled. Place a gasket of asbestos rope, heavy cotton wicking, or other suitable material (previously moistened) around the top of the still. Place the cover upon the moistened gasket and clamp securely with heavy steel clamps. Connect the exit pipe from the top of the still to the condenser by means of the union, as indicated in the diagram. Now conduct steam into the still through the inlet pipe, *E*, slowly at first, and regulate afterwards so that the distillate passing from the end of the condenser is cold or but very slightly warm. The receiving vessel, *D*, should be previously filled three-fourths full of water and placed under the exit from the condenser. Likewise, the cold water is started flowing through the condenser, as indicated by the arrow. . Frequently the oil may be led from the receiver by opening the cock on the side. However, owing to the siphon tube attached to the receiver, overflowing is impossible, since this tube carries off the water which separates in the bottom of the receiver. To ascertain when distillation is completed a few drops of the distillate as it comes from the condenser are collected in a glass test tube. The appearance of oily globules on the surface readily indicates whether appreciable quantities of oil are still passing over. Usually a distillation is completed in from one and one-half to two and one-half hours.

The advantage of steam distillation over other methods of volatile-oil extraction lies principally in its wide applicability and speed of operation. Most plants or plant parts, with the exception of the flowers in some few cases, may be extracted most readily and most expeditiously and with a minimum amount of labor by the steam-distillation method. The simplicity of the operation is obvious. The removal of the oil is much more complete than by any other process. Furthermore, there is produced as a by-product during the distillation an aqueous distillate which is completely saturated with the oil. The aqueous distillate may in many instances be utilized and sold as an "aromatic water" of commerce, especially in such cases as lavender, orange flowers, rose, etc. The aromatic waters possess excellent odors, largely because of the extreme dilution of the odorous compounds held in solution, and are useful in the perfumery and toilet-preparation industries. When the aqueous distillate from the plant has no marketable value, it may be profitably collected and returned to the boiler. In case of a further distillation of the same plant it will materially add to the yield of oil, since the distillate is a saturated solution of the oil. Many oils are extremely soluble in water. Distillates from oils of this class usually augment considerably the yield of oil when returned to the boiler and transformed into steam and oil vapors.

The spent herb, which on a large scale amounts to no inconsiderable quantity, may be used as fuel and the ash used as fertilizer, or it may be scattered upon a field and plowed under as a mulch. In some cases the spent herb serves as a useful stock food, an example of which is the peppermint grown in Michigan.

The advantages far outnumber the disadvantages of the distillation method, the only disadvantage being the possibility of slight decomposition of the ester bodies in some of the more delicate perfumed plants. However, this is only slight and almost negligible in most herbs.

HANDLING OF VOLATILE OILS.

PURIFICATION.

The volatile oil as it comes from the still is in a crude state, being contaminated by volatile substances which are formed during the distilling process by the action of the steam upon the less stable plant constituents, decomposing them into volatile organic substances, which, although trifling in quantity, nevertheless tend to affect the color, odor, and taste of the oil.

The chemical changes taking place in the still are numerous, the more important being oxidation and reduction of some of the constituents of the oil, as well as of the other plant constituents, saponification of the more unstable esters, and resinification brought about by a polymerization of certain plant constituents, all of which aid in forming volatile substances which mingle with the oil.

Although a process of purification is not always applied to these crude oils, it is important and sometimes highly profitable to subject the crude product to a process of rectification. By rectification is meant a redistillation of the oil with steam, this procedure affecting a moderate separation of the undesirable substances which may have been formed. The substances which detract from the odor of the oil are usually left behind in the apparatus as a heavy, malodorous liquid slightly resinous in character. Rectification usually results in a fine, finished product, free from foreign odors, and leaves an oil much more presentable in color as well as in odor and taste.

This process may be conducted in a miniature still built on the same general plan as the large commercial still. The loss in the amount of oil is more than compensated for by the better quality and the increased salability of the rectified oil.

SEPARATION, FILTRATION, AND DRYING.

To separate the oil from the aqueous distillate in the receiving vessel, the portion which has not been separated by means of the stop cock on the side of the receiver is poured into a separating funnel of glass and the heavier liquid drawn off. The oils resulting from

different distillations of the same plant are then united and subjected to filtration, which process tends to separate any solid particles or emulsion of oil and water. Filtration is conveniently effected by pouring the oil into a glass funnel which has been fitted with a filtering medium, such as filter paper (an unsized, porous paper) or cotton. When cotton is used as a filtering medium a small tuft may be fitted loosely into the neck of the funnel and oil poured upon it. Usually filtration takes place more rapidly through cotton than through paper and with much less loss. Rapidity of filtration is essential to minimize the possibilities of changes taking place in the oil by oxidation, since the oil is more or less exposed to the action of the air and light while undergoing this clarifying process. Hence cotton is to be recommended.

Just as the water that comprises the aqueous distillate is a saturated solution of the oil, so the oil which floats above the distillate is saturated with water. Usually it is of prime necessity that the moisture be removed from all oils, first, because of the subsequent changes that are likely to occur if moisture is present, and, second, because of the turbidity which water imparts to the oil. Hence, after filtration through cotton the oil should be dried by shaking in a bottle with a dehydrating substance, such as anhydrous calcium chlorid or anhydrous sodium sulphate, preferably the latter, owing to its lack of action upon the constituents of the oils. The crude sodium sulphate (Glauber's salts) may be dehydrated by heating it in a vessel over direct heat, with constant stirring until a dry, grayish powder results. But a small quantity is necessary to abstract the moisture from an oil. After the oil has been dried it is again filtered through a light plug of cotton. A clear and transparent oil finally results, bearing in every way the appearance of a marketable oil.

PRESERVATION.

Many constituents of volatile oils are of such a nature that unless the strictest precautions are observed in storing the oils chemical decomposition takes place, causing them to change in both odor and color, thereby reducing the quality and value. The esters of an oil (combinations of organic acids with alcohols) are very prone to decomposition, as are also many aldehydes and hydrocarbons, which either through saponification, hydration, oxidation, reduction, or polymerization become totally different substances. These chemical processes are usually stimulated by the action of light and air upon the oils. Therefore, in order to guard against these changes and to minimize them as much as possible, the strictest attention should be paid to the proper bottling and storage of the oils.

It is of the utmost importance that all oils should be placed in bottles which are well filled. The absence of air is of the greatest importance in insuring the preservation of an oil. The oxygen of the air, assisted by light, becomes extremely energetic in bringing about some of the changes previously mentioned. It is therefore of import that the oils be kept not only in well-filled, tightly stoppered bottles, but in a dark place. It is sometimes convenient and advisable to use amber-colored bottles in order to prevent the entrance of the actinic rays of light which are so active in causing polymerization. A cool place is also to be preferred for the storage of volatile oils.

All undue exposure of oils to the action of light and air should be avoided as much as possible. It is necessary that an oil from the time it leaves the receiving vessel after distillation or rectification until it is filtered, dried, and bottled should be handled with care and dispatch to insure a product of the best quality and appearance.

GROWTH AND HARVESTING OF PERFUME PLANTS.

CLIMATE AND SOIL.

Up to the present time the cultivation of perfume-yielding plants has not been carried on, even experimentally, over a very large part of the United States, and such work of this sort as has been done is confined to but a few kinds of plants. Until our knowledge along these lines has been very much increased by practical attempts to cultivate this class of products, only statements of probabilities can be made. However, in some cases plant introductions along other lines from the oil-yielding countries of the Old World, together with information as to conditions of climate and soil in those regions, give a basis for surmise in connection with these crops. The wide diversity in climate and soil in different parts of the United States, with the varying conditions of heat, light, and moisture, renders it probable that some portions of the country will be found to be well fitted for the cultivation of the perfumery plants characteristic of the temperate zones. It appears probable that the conditions prevailing in those parts of Europe associated with the perfumery industry can be fairly well duplicated. It will doubtless require much experimental work to find the particular localities best suited to special plants.

It must be borne in mind, however, that not only must conditions of soil and climate be right but that the labor conditions which go with the problem must be met in a practical way. The distance of the point of production and the transportation factors are also important and might be decisive.

Some work on perfumery-plant growing has been carried on in Florida, notably by Mr. E. Moulié, of Jacksonville, whose experience has been distinctly encouraging. Experiments by Mr. S. C. Hood with a number of oil-yielding grasses grown in the testing garden carried on by the Bureau of Plant Industry at Orange City, Fla., give good ground for hope that a number of kinds of plants able to endure a little freezing weather may be cultivated with good results. California and the arid Southwest offer promising conditions for plants which thrive in dry, sunny locations. Michigan, Indiana, and New York are already well known as important centers for the production of peppermint, spearmint, and erigeron oils, while Michigan, Wisconsin, Nebraska, and other States in the north-central part of the country form a most important source of wormwood oil. Doubtless other oil-bearing plants now on trial may be found to do well in parts of the same general section. American wormseed (*Chenopodium* spp.) is distilled in Maryland and southward, and sassafras is distilled in various places, especially in the mountains, from Pennsylvania southward. The oils of wintergreen, sweet birch, spruce, and white cedar are derived from the more northern ranges of the Atlantic slope. The mountainous regions of Tennessee and Kentucky supply wintergreen, sweet birch, and sassafras oils.

It is thus apparent that a number of native and introduced plants rich in volatile oils have obtained foothold on a commercial basis in this country, and there is good ground to hope that products of this general class now obtained from abroad may in time become naturalized here.

GROWTH AND CULTIVATION.

Several methods of procedure with regard to the propagation and cultivation of volatile-oil and perfume-yielding plants are to be followed, depending largely upon the nature and habitat of particular species of plants. Annual plants such as are grown from seeds and which blossom and mature the same year are rather common among volatile-oil plants.

The details of cultivation and handling vary somewhat with the crop grown and are a matter for careful field study. In general, the annuals are either fall or spring sown, depending upon soil and climate, some seeds germinating best if left in the ground over winter, as is the case with pennyroyal. Row culture is advisable in order to secure better cultivation and a consequent freedom from weeds.

Perennials are in some cases grown well from seed, as caraway and wormwood, but in some cases, such as spearmint, peppermint, sage, rose, and lavender, propagation from cuttings or roots is preferable.

The method of handling must be adapted to the particular plant to be grown.

A thorough cultivation of the field is necessary to eliminate all weeds, both between the rows and in the rows themselves. This is of the utmost importance, since weeds, although as a rule not containing any volatile oil, do possess volatile substances which are set free by the steam should the weeds become mixed with the aromatic plant. A contamination of the oil and a depreciation in the aromatic qualities will result unless the material is kept free from weeds and other rank growths.

HARVEST.

Possibly no stage in the cultivation and production of volatile oils from plants is of greater importance than that of the proper harvesting of the crop. It is usually conceded that most perfume plants reach their maximum development as regards odor, both in quality and quantity, at the flowering period. On the other hand, many authorities are of the opinion that as soon as a plant reaches its full flowering period there sets in a gradual consumption of the odorous principles; hence, the harvest should be made prior to this consuming process.

Experiments recently conducted for the purpose of determining the amounts of odorous constituents of several plants present at various stages of development seem to indicate that both the quality and the quantity of the oils vary appreciably during their successive stages of development, but no evidence was obtained to show that consumption of odor took place during flowering. However, it was proved that the odor was developed during the advance in growth and the approach of the flowering period.

Three typical plants were used as a basis of experiment, viz, peppermint (*Mentha piperita*), bergamot mint (*Mentha citrata*), and wormwood (*Artemisia absinthium*), the oil of each of which owes its characteristic fragrance to esters which admit of being measured quantitatively with some accuracy. The plants were grown under like conditions and distillations conducted at three well-defined stages of advancement, namely, (1) before flowering (or while in the budding state), (2) at flowering, and (3) after flowering (or during the fruiting stage).

The effect of successive stages of growth upon the esters and the alcohol only will be considered here, although other constituents, and especially the terpenic compounds, also suffer changes.

To picture more clearly the results of the experiments and the changes observed in the oils, tabulations were made as follows:

TABLE I.—*Yield of oil and changes observed in plants at different stages of growth.*

PEPPERMINT (MENTHA PIPERITA).

Stage of growth.	Yield of oil.	Ester content as menthyl acetate.	Alcohol content as free menthol.
	Per cent.	*Per cent.*	*Per cent.*
Before flowering (July 22)	0.23	9.5	31.0
At flowering time (August 21)	.20	14.5	23.6
After flowering (September 25)	.10	24.0	34.0

BERGAMOT MINT (MENTHA CITRATA).

Stage of growth.	Yield of oil.	Ester content as linalyl acetate.	Alcohol content as linalool, free.
	Per cent.	*Per cent.*	*Per cent.*
Before flowering (July 20)	0.32	47.6	7.3
At flowering time (September 22)	.37	55.0	7.3
After flowering (October 14)	.22	52.0	5.5

WORMWOOD (ARTEMISIA ABSINTHIUM).

Stage of growth.	Yield of oil.	Ester content as thujyl acetate.	Alcohol content as thujyl alcohol, free.
	Per cent.	*Per cent.*	*Per cent.*
Before flowering (July 2)	0.19	26.0	14.7
At flowering time (July 14)	.18	32.5	11.7
After flowering (August 4)	.10	47.5	12.0

It is obvious from these results that in two cases, with peppermint and with wormwood, the aromatic quality of the oil, if measured by the percentage of esters, is increased gradually during each stage of growth, the percentage of free alcohol remaining fairly constant. In the peppermint the oil from the "after-flowering" stage was noticeably more fragrant than the oils from the two earlier stages. The yield of oil remains fairly constant up to the last stage, when there is a marked diminution. The plant in the first two stages is very much the same as regards moisture content, while the low percentage of oil from the plant after flowering, when it possesses much less succulency, may be attributed to the consumption of other constituents than the esters and alcohol. This applies to all of the plants which seem to follow the same general course in this respect.

The oils from the bergamot mint disclose a very slight decrease in ester content and alcohol content in the "after-flowering" stage.

The decrease is so slight, however, as not to warrant the statement that a consumption of odor has occurred.

It must be understood that these results are proposed only tentatively and that further experiments will be carried on to prove or disprove the conclusions drawn.

Employing the aforementioned plants as typical examples, the harvest period, in order to attain a maximum yield of oil with a correspondingly high percentage of odorous constituents, should begin as soon as the plant is fully blossomed. A delay of the harvesting until the "after-flowering" stage is reached apparently increases somewhat the quality of the odor, but this increase is largely overbalanced by the decrease in the yield of oil, which is of paramount importance to the grower.

The proper preparation of the material prior to distillation is not to be overlooked, since the quality and the quantity of the oil are varied considerably by improper handling and by partial or complete drying of the fresh plant before it enters the still.

To illustrate this point more clearly, practical instances will be mentioned to show the effect of drying upon the quality and the quantity of the oil from plants. The three examples previously mentioned will be used as a basis for the comparison of the oils from fresh and dry material. In order to obtain a rational and logical means for comparing the oils, fresh, green plants of peppermint, bergamot mint, and wormwood were cut during the height of their blossoming stage. The herb in each case was divided into two equal parts, one half of which was set away to dry and the other half distilled immediately. The oils obtained were later analyzed for the esters and the alcohols, and the results obtained are presented in Table II.

TABLE II.—*Yield of oil and percentages of esters and of alcohols obtained from fresh and from dry plants.*

PEPPERMINT (MENTHA PIPERITA).

Condition of plant.	Date of distillation.	Yield of oil.	Menthyl acetate.	Menthol.
		Per cent.	*Per cent.*	*Per cent.*
Fresh	August	[a] 1.50	10.5	48
Dry	December	.55	18.0	47

BERGAMOT MINT (MENTHA CITRATA).

Condition of plant.	Date of distillation.	Yield of oil.	Linalyl acetate.	Linalool.
		Per cent.	*Per cent.*	*Per cent.*
Fresh	September	[a] 1.30	33.0	45
Dry	December	.75	51.8	43

[a] Calculated from dry weight.

TABLE II.—*Yield of oil and percentages of esters and of alcohols obtained from fresh and from dry plants*—Continued.

WORMWOOD (ARTEMISIA ABSINTHIUM).

Condition of plant.	Date of distillation.	Yield of oil.	Thujyl acetate.	Thujyl alcohol.
		Per cent.	*Per cent.*	*Per cent.*
Fresh	August	0.60	32	41
Dry	December	.44	35	15

These data with respect to the oils from fresh and dry herbs readily illustrate that during the drying of the plants certain factors, assisted by exposure to air and light, undoubtedly bring about chemical changes in the aromatic constituents, which evidence themselves in the final analyses of the oils.

It will be noted that the yield of oil decreases 63⅓ per cent in the case of peppermint, while the percentage of decrease of oil from bergamot mint is nearly 43, and from wormwood about 27 per cent. These marked decreases are in part due to the long period of drying, but they at least show that there is a downward tendency, which is very natural considering the volatility of the constituents.

In all three cases there seems to be an increase in the percentage of esters, with a decrease in the percentage of alcohol, in the dried herb, the chemical changes no doubt being such as to facilitate the production of esters and to break down the alcohols. Apparently the alcohols seem to be more unstable, condensing with the organic acids in the plant under favorable conditions of heat, light, and moisture to form esters. This latter change is especially noticeable in all the oils, the dry-herb oils being considerably richer in esters than the fresh-herb oils, and correspondingly poorer in alcohols.

In order to produce the largest yield of oil from a given quantity of herb, distillation should be made immediately after harvesting. There is no noteworthy advantage in drying or even partially drying the plant, since the longer the time between the cutting and the distilling the more volatile oil will be lost by gradual evaporation or volatilization. Although the quantity of oil capable of being carried off into the air by simple drying seems only trifling, nevertheless, on a large scale the loss would be considerable. The increased proportion of the odoriferous esters in the oils from dry herbs is insufficient to warrant the drying of the plants before distillation, because of the loss of oil encountered during the drying process.

VOLATILE OIL PLANTS OF THE UNITED STATES.

At the present time the number of plants in the United States yielding volatile oils in a commercial way is very small, but the number capable of yielding oils of probable value is correspondingly

great. There is, in fact, a large number of odoriferous plants still uninvestigated which should demand consideration. As yet but little research has been undertaken which would tend to increase the number of valuable aromatic plants now being utilized. A study of this particular phase of the subject, coupled with the introduction of foreign species into the United States, should eventually develop somewhat the resources of the country along this important line.

CULTIVATED PLANTS.

The relatively small number of volatile-oil-yielding plants at present under cultivation and the success of the industry based on these few plants should be sufficient justification for widening the scope of our efforts.

The cultivated plants at the present time are principally the mints, peppermint and spearmint, together with small quantities of such plants as wormwood, tansy, and wormseed.

The distillation of peppermint[a] and spearmint in the United States dates back to 1816, when the peppermint plant was first cultivated for the production of the oil in New York, followed somewhat later by spearmint. The cultivation gradually spread, until at present the center of the industry is in Michigan, with limited production in Indiana.

The cultivation in New York and Michigan has decreased recently, owing to a slight oversupply, which, however, is probably only temporary. Peppermint and spearmint are possibly more largely distilled in the United States than any other oils at the present time, excluding such plants as grow wild and which produce large quantities of oil, notably the turpentine-yielding pines.

The wormwood plant (*Artemisia absinthium*), although introduced from Europe, has been cultivated to some extent commercially in Wisconsin, Michigan, New York, and other North-Central States. The distillation of the oil has been conducted with a certain degree of success, the yield from fresh, flowering herbs being from one-third to one-half of 1 per cent. It is, however, questionable whether, in the light of the recent European agitation against wormwood, this plant will continue to be cultivated for its oil to the same extent as in the past.

The herb tansy (*Tanacetum vulgare*) is grown for its oil in a small way in the eastern part of the United States and yields from one-tenth to one-fifth of 1 per cent of a volatile oil used principally in medicine.

The plant American wormseed (*Chenopodium ambrosioides* L., var. *anthelminticum*) is grown chiefly in Maryland and southward,

[a] Bulletin 90, pt. 3, Bureau of Plant Industry, U. S. Dept. of Agriculture

where the plant is found growing wild. There are produced the seeds, which are valuable commercially, and the volatile oil distilled therefrom, which also possesses the anthelmintic action of the seeds.

Another volatile oil which is produced on a very extensive scale and which has been distilled commercially for more than a century, namely, oil of turpentine, deserves brief mention. The production of turpentine oil is confined principally to the Southern and Gulf States, from Virginia to Florida, regions of extensive pine forests. Turpentine is obtained as an oleoresinous exudation from several varieties of pine trees, chief among which is the long-leaved pine (*Pinus palustris* Miller). Other species, such as *Pinus taeda* L. and *Pinus echinata* Miller, also yield a valuable oleoresin. Unlike most volatile oils, the oil of turpentine is not distilled directly from the plant but results as one of the products of the distillation of the oleoresin obtained from the trees, the other product being the rosin or colophony of commerce. The usefulness and value of oil of turpentine in commerce, both in the arts and in medicine, where it is practically indispensable, require no further comment.

The plants just enumerated represent the principal volatile-oil plants which are cultivated or gathered for oil production in the United States. The distillation of oils from the mint species is a singular instance of an industry of commercial magnitude, while the several other oils which are being distilled from cultivated plants occupy a secondary position in production. The further development of some of the oils mentioned will be controlled largely by the consumption of the products and by the demand which may be created for them.

The experimental work being conducted at the present time at the Arlington Experimental Farm, near Washington, D. C., is such as to demonstrate the practicability of more extensive cultivation of the plants already grown, as well as of other plants growing wild at present, but which by proper methods of domestication can probably be greatly improved both from the standpoint of luxuriance of growth and of fragrance.

The introduction of foreign species of volatile-oil plants and the testing of the same upon native soil are also receiving considerable attention, and the successful production of oil is clearly assured in some cases. Suitable localities, however, must be chosen to conform with the natural habitats of the introduced plants in order to attain the highest degree of efficiency of production.

WILD PLANTS.

Possibly the number of wild aromatic plants which are used in the manufacture of volatile oils exceeds that of those which are at present

cultivated. The extent of the production of the oils is much less, chiefly because of the more or less scattered condition of these plants, and therefore the difficulty of gathering them in large quantities. Usually these wild aromatic plants are distributed over wide areas confused largely with other volatile or nonvolatile species, thus causing the rapid collection of the plants to be seriously hindered. For this reason, probably, together with lack of interest in the cultivation of the wild plants, the production of their oils has been largely restricted.

SASSAFRAS.

A specific example of an important uncultivated plant which yields a volatile oil of considerable value is the sassafras tree. Sassafras oil was one of the first volatile oils distilled in America. The range of the tree is from Florida, where it was originally discovered, to Virginia and Pennsylvania, and even as far north as New York and the New England States. It is quite abundant in the South-Central States, especially Kentucky, Tennessee, and Arkansas. The production of this oil attained commercial significance early in the last century, and it is distilled extensively at present in Kentucky, Tennessee, Pennsylvania, Maryland, and Virginia; also to a less extent in Ohio, Indiana, and New York.

Although the distillation of this very fragrant oil, which is obtained principally from the bark of the root of the sassafras tree (*Sassafras officinalis*), has assumed a strong commercial aspect, the tree has not been grown, strictly speaking, for oil purposes. No doubt the great abundance and the ready accessibility of the trees growing wild are the causes of the noncultivation of this tree for commercial purposes. The leaves and branches of the tree are faintly aromatic, but are not used as a source of the oil. The root bark and wood, which contain from 1 to 8 per cent of volatile oil, form the crude source of supply. The oil is distilled by the ordinary method of steam distillation, the wood and bark of the root being previously coarsely comminuted to admit of better extraction.

WINTERGREEN AND SWEET BIRCH.

The distillation of the oils of wintergreen and sweet birch is a further example of wild aromatic plants furnishing oils in sufficient quantities to supply the trade. Both wintergreen (*Gaultheria procumbens*) and sweet birch (*Betula lenta*) occur largely from the New England States and North-Central States to Georgia, Florida, and Alabama. The distillation of these oils dates back nearly as far as that of the oil of sassafras and has developed until the industry at present is of some significance. Wintergreen and sweet birch are entirely unrelated plants, yet the oils produced from them by di-

tillation are for all practical uses identical. Mention has been made previously of the fact that the oil in these plants is formed by reaction and does not preexist in the tissues. The glucosid gaultherin is the constituent which is responsible for the formation of this oil, and since the reaction between this glucosid and the plant ferment is the same in both plants, the resulting volatile oil (or methyl salicylate) must necessarily be similar.

In the case of the sweet birch, which is a tree of some size, the bark of the trunk and the small branches are used for distillation, being previously cut into small pieces and allowed to macerate with water before introduction into the still. A yield of three-tenths to three-fifths of 1 per cent of oil is obtained. On the other hand, for the separation of the oil of wintergreen the leaves and twigs are used, the plant being more or less shrubby. The same treatment is applied to wintergreen as to sweet birch, maceration in water being allowed to continue for a period of several hours prior to distillation. The yield of volatile oil from wintergreen varies from one-half to 1 per cent. Owing to the abundance of these plants their cultivation especially for the volatile oil has not been attempted, the material being collected from the plants as they grow in their native habitats. The strict enforcement of the Food and Drugs Act has tended to curtail largely the use of the synthetic oil (methyl salicylate) for certain purposes where the natural oil is required. A more active demand for the natural oils of sweet birch and wintergreen has necessarily resulted, the price of these oils being thereby materially advanced.

CANADA FLEABANE.

Several other plants capable of yielding volatile oils of some value are at present distilled in the United States. A very common herb growing abundantly in the North-Central and Western States, the Canada fleabane (*Erigeron canadensis*), usually regarded as a weed and known to westerners as the fireweed (not the true fireweed, however), is distilled in a small way in connection with the distillation of peppermint. The plant, which is a hardy annual, is not cultivated, but is cut in the wild condition, no special care being taken to eliminate other aromatic weeds or plants, and consequently there results an oil which, although representing the oil of erigeron, is far below the true standard of the oil, owing to the presence of extraneous plant matter introduced during distillation.

EUCALYPTUS.

The production of eucalyptus oil from the leaves and twigs of the blue-gum tree (*Eucalyptus globulus*) is of considerable importance in the volatile-oil industry of the United States. The commercial

production of this oil is confined almost exclusively to the State of California, where the tree grows abundantly. The tree is not cultivated as a source of volatile oil, but is extensively grown for ornamental, fuel, and timber purposes. The leaves and twigs are collected from the waste branches or brush resulting when the trees are cut for timber or wood and used for the purpose of distillation. The material selected for distillation may be coarsely comminuted and the essential oil readily obtained therefrom by the usual method of steam distillation.

The yield of oil varies from three-tenths to four-fifths of 1 per cent, according to the quantity of woody branches and twigs introduced into the still with the leaves, the latter producing the highest yield of oil. The use of this oil is very general, and it is employed chiefly as a therapeutic agent. From 70 to 90 per cent of the oil consists of eucalyptol or cineol, the chief constituent and the one to which its valuable antiseptic properties are due.

The waste leaves and branches accumulating when the trees are cut for lumber or wood are not fully utilized. At points where a considerable number of trees are being felled a distilling apparatus could under favorable circumstances be profitably installed and successfully operated at a very moderate expense. It has been estimated that 2 tons of leaves and twigs will produce from 3 to 4 gallons of oil at a cost of about $3 a gallon for distilling the oil.[a]

MONARDAS.

Two additional plants possessing volatile oils of antiseptic value and growing wild in the whole north-central portion of the United States, from Pennsylvania to Minnesota, are wild bergamot (*Monarda fistulosa*) and horsemint (*Monarda punctata*), belonging to the Labiate tribe. These plants yield oils rich in antiseptic constituents, the former producing an oil consisting chiefly of the liquid phenol carvacrol, while the oil from the latter consists for the most part of the crystalline phenol thymol. Both of these constituents are isomeric in character and of equal value as antiseptics, the extensive use of thymol for medicinal purposes being familiar to most people.

Wild bergamot and horsemint, owing to their hardiness, are capable of profitable cultivation in the North-Central States, where the climatic conditions seem to be especially suitable for their growth and for the production of oil. The whole fresh plant during its flowering condition is generally distilled, the amount of oil obtained being influenced by conditions of growth and culture, but averaging from three-tenths to 1 per cent or more. The perennial nature of the plants enables the grower to produce them from year to year with a mini-

[a] Bulletin 196, California Agricultural Experiment Station, p. 34.

mum of labor on somewhat sandy, dry soil which possibly has no great value for the production of other crops.

PENNYROYAL.

Pennyroyal is a small annual herb characteristic of the east-central portion of the United States. It is distilled for its oil principally in Ohio and North Carolina, with smaller operations in intermediate States. The pennyroyal plant (*Hedeoma pulegoides*) is native to the United States, is readily propagated and grown, and yields a volatile oil which finds extensive application in therapeutics. The yield of oil distilled from the fresh flowering herb varies from three-fifths to 1 per cent.

MISCELLANEOUS AROMATIC PLANTS CAPABLE OF CULTIVATION.

The foregoing instances represent typical cases of wild plants indigenous to the United States and capable of yielding volatile oils, some of which are distilled on a quasi-commercial basis while others are not grown or distilled at all.

Hosts of other wild aromatic plants are found growing in all sections of the country, many possessing exceedingly fine fragrance and many, on the other hand, possessing odors less attractive but nevertheless possibly of value. These odorous plants will in most cases produce volatile oils which may contain constituents of value, not only in the perfumery trade but also in the arts and medicine. A systematic canvass of the flora of the United States, with special attention to those plants which possess an aroma, and a trial distillation of the same, followed by a careful, detailed chemical examination of the oils, will no doubt bring to light new oils, the value of which may be determined from the nature of the constituents identified in them. Several new volatile oils have been distilled within the past year which have been shown by chemical analysis to contain highly valuable constituents. The results of these experiments, which have proved very gratifying, will be published in the near future, and the significance of the exploration in this field of research will be clearly indicated. Practically no progress has been made in this direction within the last few decades. The necessity of these investigations is therefore strongly recommended.

Various other plants deserving mention, besides those already cultivated and those growing wild which possess volatile products of value to the perfumer and confectioner, are the rose, lavender, rose geranium, rosemary, thyme, sweet basil, summer savory, and sweet marjoram, and the umbelliferous seeds (caraway, anise, fennel, and coriander), besides the citrus fruits lemon and orange. The plants of the first general class, though not native to this country, have been

introduced and grown as garden plants, luxuriant growth and excellent aromas usually being obtained.

The umbelliferous plants mentioned have also been largely grown, although only on a garden scale, usually for their seeds, which possess considerable value to the housewife and to the confectioner for flavoring or condimental purposes. The distillation of the oils from these seeds has been very largely for experimental purposes only.

The citrus fruits, although grown very extensively, have received but slight attention in the United States from the standpoint of their volatile oils, which are of so much value to the scenter and perfumer.

The rose, lavender, and rose geranium, although possessing exceedingly fragrant volatile oils have received only trifling consideration as regards cultivation for the aroma.

It is not unlikely that certain sections of the United States are adapted to the growth of the Bulgarian rose, which produces the rose oil of commerce. In order to locate these desirable regions, practical tests would be required, attention being paid to the quality of the perfume obtained and also to the labor required in the gathering of the rose petals. Besides the usual variety of rose used for perfume cultivation, the *Rosa damascena*, there are a number of other species which have become naturalized in this country and which possess fragrance of exceedingly high quality, besides being prolific bearers.

Experiments in connection with the growing of roses for perfumery purposes are worthy of attention in some of the southern portions of the United States where the conditions of climate are especially favorable and where, since the petals must be plucked by hand for distillation, labor would be sufficiently cheap to insure a certain degree of success.

Lavender (*Lavandula vera*), now grown extensively in the semi-mountainous districts of France and in England for the volatile oil, is no less capable of growth on the soils of this country than other plants which are at present grown profitably. The regions of growth in France, Italy, and England are not entirely dissimilar and do not possess any more suitable climatic and soil conditions than might be supplied in some sections of the United States. In this case experiments would also be necessary to locate desirable regions, but the labor factor would be minimized considerably owing to the fact that the entire tops of the plants are distilled. Owing to the little labor required in connection with lavender, enterprise in this matter should not be lacking.

The rose geranium (*Pelargonium odoratissimum*), a plant with an exquisite odor grown and distilled in France, Spain, Algiers, and the island of Reunion, deserves some consideration with regard to cultivation, inasmuch as the oil distilled from the plant is of such

a nature as to make it almost indispensable in the perfumery industry. Unlike that of lavender, the odor of the rose geranium resides in the leaves, the flowers being almost odorless. Experiments in a preliminary way are now being carried on to determine the quality of the oil capable of being distilled from this plant. As in the case of the rose and lavender, the most suitable location can be learned only by a system of tests in localities with different climatic and soil conditions.

Rosemary (*Rosmarinus officinalis*), thyme (*Thymus vulgaris*), sweet basil (*Ocimum basilicum*), summer savory (*Satureja hortensis*), and sweet marjoram (*Origanum marjorana*), besides others of this type originating in Mediterranean countries and yielding oils of excellent fragrance for both the perfumers and the toilet-preparation manufacturers, can by proper attention and perseverance no doubt be produced advantageously. A factor of considerable import in the growth and distillation of these plants is that whole fresh herbs can be distilled, thus obviating the necessity of picking the flowers by hand.

The distillation of oil from such seeds as caraway, anise, fennel, and coriander, which are so universally used for flavoring and scenting purposes, has been successfully exploited in southern Europe for decades. These seeds have been introduced into the United States and grown in small quantities, principally for household use. The ease of production as a household necessity should be sufficient stimulus for growing the plants on a broader basis for the distillation of the very fragrant oils. The North-Central States, with their excellent soil and climate, undoubtedly are capable of producing profitable yields of seeds giving from 2 to 7 per cent of volatile oil. The method of distillation is similar to that of leaves or herbs, with the exception that, in order to facilitate the permeation of the steam, the seeds are ground coarsely before being subjected to the steam vapors.

The commercial isolation of oils from citrus fruits and their by-products centers principally in Sicily and Italy. The production of oil from either lemon or orange peel in the citrus regions of California has received but slight attention and should be deserving of more, inasmuch as the demand for these oils is very constant and the prices reasonably high. The distillation of waste lemons or unsalable lemons would possibly yield a volatile oil of fair quality, which no doubt would find a ready market. The Sicilian methods of hand expression are practically out of the question because of the labor factor involved. The distillation of lemon-tree prunings yields an oil of extremely high citral content, which should prove valuable for flavoring purposes.

COMMERCIAL ASPECT OF THE INDUSTRY.

VALUE AND CONSUMPTION OF VOLATILE OILS.

Mention has already been made of the value in general of volatile oils as industrial products, which commercially have not been manufactured in the United States to any extent, the mint oils being singular exceptions. Lack of interest in the growth and development of perfumery plants is principally responsible for the inactive condition now existing in this important phase of industrial enterprise. Possibly a lack of experience with regard to the growth of the plants concerned and the methods necessary for success has been largely instrumental in preventing the upbuilding of this branch of industry.

It must be conceded that very large quantities of volatile oils are at present consumed in the United States in the several uses to which they are applied. In the manufacture of perfumes the rôle played by volatile oils is all important. A large proportion of the amounts consumed enters the channels of the perfumery trade. Usually perfumes consist of blends of odors brought about by a skillful combining of several oils in varying proportions through a medium capable of holding in solution these oils and odoriferous ingredients. The manufacture of perfumes has shown but little development in the New World. Perfumery products are largely imported in the prepared condition, chiefly from France, where the skillful art of compounding has been scientifically developed.

The use of volatile oils in flavoring and in the manufacture of flavoring extracts is very extensive, but it is restricted to a comparatively small number of oils, principal among which are lemon, orange, wintergreen, peppermint, and others of this type.

For scenting purposes, such as aromatizing soaps and toilet preparations in general, volatile oils have been employed very extensively in the United States. Their use in this line of application has increased with the increase in the manufacture of these much-demanded articles.

On the other hand, the medicinal value of certain oils and of certain constituents which can be isolated from them has created a demand which in part has been supplied by home production and in part by foreign production. The separation of important therapeutic ingredients, chiefly antiseptics, has been highly serviceable in the treatment of many ailments, a striking instance of this kind being the separation of camphor from the oil of camphor, this ingredient playing an important rôle in medicine as well as in the arts. Other oils deserving mention in this connection are those of eucalyptus and thyme, the former yielding the valuable eucalyptol and the latter thymol. Another example is peppermint oil, from which

menthol is isolated. All of these constituents possess therapeutic value of no little importance.

In order that the grower may become acquainted with the approximate value of volatile oils on the American market, the following tabulation of prices has been prepared. The perfumery articles listed include the principal volatile oils which enter the markets of the United States for consumption, the prices being current wholesale quotations in effect in January, 1910. Prices are per pound unless otherwise stated.

Wholesale prices of various volatile oils in the markets of the United States, January, 1910.[a]

Almond, bitter	\$3.25 to \$4.75
Anise	1.10 to 1.12½
Bay	1.90 to 2.00
Bergamot	3.75 to 4.00
Cade	.16 to .20
Cajeput	.52½ to .55
Camphor	.09 to .10
Caraway seed	1.15 to 1.25
Cedar, leaf	.42½ to .45
Cedar, wood	.16 to .17
Cinnamon	6.50 to 12.00
Citronella	.25 to .28
Cloves	.70 to .72½
Copaiba	1.00 to 1.10
Coriander	5.00 to 6.00
Cubeb	3.00 to 3.25
Erigeron	1.50 to 1.60
Eucalyptus, American	.35 to .60
Fennel seed	1.10 to 1.30
Geranium, rose, African	3.50 to 4.00
Geranium, rose, Turkish	2.25 to 2.50
Ginger	4.00 to 4.50
Ginger grass	1.10 to 1.35
Hemlock	.45 to .50
Juniper, berries	.80 to 1.00
Juniper, wood	.23 to .25
Lavender, flowers	1.85 to 2.25
Lavender, spike	.60 to 1.10
Lemon	.77½ to .85
Lemon grass	.80 to .85
Lime, expressed	1.75 to 2.00
Lime, distilled	.55 to .60
Linaloe	2.80 to 2.85
Mace	.70 to .75
Male fern	1.90 to 2.20
Mustard	3.00 to 4.00
Neroli, petals	50.00 to 75.00
Neroli, bigard	35.00 to 50.00

[a] Oil, Paint, and Drug Reporter, vol. 77, no. 4, January 24, 1910, p. 32.

Nutmeg		$0.70	to	$0.80
Orange, bitter		2.25	to	2.35
Orange, sweet		2.20	to	2.40
Origanum		.20	to	.40
Patchouli		4.00	to	4.25
Pennyroyal		1.70	to	1.80
Pennyroyal, French		1.40	to	1.50
Peppermint, tins		2.00	to	2.10
Peppermint, bottles		2.30	to	2.35
Petit grain, French		5.00	to	6.00
Petit grain, South American		2.40	to	2.75
Pimento		1.90	to	2.25
Rose, natural	per oz.	5.00	to	5.50
Rosemary flowers		.67½	to	.75
Safrol				.40
Sandalwood		3.00	to	3.25
Sassafras		.55	to	.65
Savine		1.25	to	1.30
Spearmint		1.75	to	1.85
Spruce		.40	to	.45
Tansy		2.50	to	2.75
Thyme		1.00	to	1.10
Wintergreen (or sweet birch)		1.45	to	1.75
Wintergreen, leaf		3.25	to	4.25
Wormseed		1.50	to	1.60
Wormwood		6.25	to	6.50
Ylang-ylang		47.00	to	65.00

IMPORTS AND EXPORTS OF VOLATILE OILS.

Importations of volatile oils and allied products have increased from year to year until at the present time the expenditures for volatile oils and perfumes aggregate more than $2,000,000 annually.

According to the statistics of imports compiled by the Bureau of Statistics of the Department of Commerce and Labor, the importation of volatile and distilled oils, free and dutiable, for the year ending June 30, 1908, amounted to $3,619,161.33.[a] From this amount there should be deducted $886,923, which represents distilled oils not of plant origin. The total importation, therefore, of volatile oils, free and dutiable, distilled from plants for the above year was valued at $2,732,238.33. These figures represent only the volatile oils imported.

In addition to the sum mentioned, the imports of alcoholic perfumery, including toilet and cologne waters and alcoholic handkerchief perfumes, must be considered. The total imports of this class of perfumes for the year ending June 30, 1908, amounted to $484,498.43.[a]

[a] Commerce and Navigation of the United States, 1908, p. 917.

The value of toilet preparations, such as cosmetics, hair washes, dentrifices, pastes, pomades, and powders, into which perfumery substances enter may also be mentioned in this connection. The imports of these preparations for the above year reached a total of $604,258.09.[a]

For purposes of comparison and to illustrate the remarkable increase of consumption of volatile oils of foreign production, the statistics extending over several years are tabulated.[b]

TABLE III.—*Imports of volatile and distilled oils for the years ending June 30, 1903 to 1908, inclusive.*

Free imports from—	1903.	1904.	1905.	1906.	1907.	1908.
Europe	$1,253,360	$1,318,606	$1,337,268	$1,617,796	$2,227,530	$2,215,265
North America	2,747	1,315	16,889	5,713	2,431	5,996
South America	2,364	4,052	2,205	750	4,969	11,886
Asia	191,730	252,729	176,563	308,781	407,008	311,688
Oceania	129	....	....	....	....	....
Africa	....	290	24	....	304	....
	1,450,330	1,576,992	1,582,449	1,933,040	2,642,242	2,550,835

TABLE IV.—*Imports of volatile and distilled oils for the years ending June 30, 1903 to 1908, inclusive.*

Dutiable imports from—	1903.	1904.	1905.	1906.	1907.	1908.
Europe	$590,493	$745,013	$865,008	$850,989	$987,919	$1,028,630
North America	14,444	12,210	4,994	12,794	18,879	15,678
South America	....	....	....	15	....	415
Asia	86,768	41,214	54,296	38,361	32,572	22,441
Oceania	14,296	20,958	24,343	15,529	17,123	19,308
Africa	....	361	8,003	12,227	3,485	8,134
Total	706,001	819,756	951,644	929,915	1,059,978	1,094,606

The steady increase in the importation of perfumery products, as shown in Tables III and IV, indicates that the consumption of volatile oils and scenting materials in America is also increasing. With the exception of peppermint, comparatively small quantities of crude oils are distilled and exported from the United States. The exports of peppermint oil, distilled largely in New York and Michigan, for the year ending June 30, 1908, were 141,617 pounds, valued at $357,555,[c] while all other essential oils exported amounted to $214,765.

The imports of volatile oils and perfumery materials far exceed the exports of the same products, the principal product of export being peppermint oil, a singular case where the distillation approaches industrial size in the United States.

[a] Commerce and Navigation of the United States, 1908, p. 919.

[b] Commerce and Navigation of the United States, 1908, p. 279.

[c] Commerce and Navigation of the United States, 1908, p. 636.

The total yearly outlay for the crude materials, and also for the finished products, is sufficient to attract attention and is deserving of concerted action on the part of growers and others who might profitably engage in this neglected field of research and practice.

PRESENT SOURCES AND COST OF PRODUCTION OF VOLATILE OILS.

The present source of these commercial products, which may be gleaned from the tabulation, is Europe, from whence they are imported both in the crude state and in the manufactured condition. Italy possibly furnishes the smallest quota of volatile oils and the largest valuation, the products being chiefly the citrus oils, supplied solely by Sicily and Italy and consumed to a great extent in the United States. From France the large proportion of perfumery extracts and finer essential oils is imported, while Germany, Turkey. and Great Britain distribute to this country large consignments of crude and purified volatile oils.

The Mediterranean regions of Europe are the chief sources of these aromatics, which are so generally employed in the industries in diverse ways. The cost of production is minimized in these countries because of the cheaper class of labor as compared with labor in America, for instance. In the handling of many flowers and plants, much hand labor is required, especially in the collection of the material prior to distillation. The actual distillation and purification of the oils can be conducted with equal economy in the United States, while in the case of no small number of plants which may be suitably collected and distilled in the whole condition the question of labor becomes a less serious factor, especially in some instances where mowing machines may be employed advantageously to harvest the crops. Where hand picking is required, as in the case of some of the more delicate odors from flowers and flowering tops, cultivation and extraction of the odor could possibly be carried out in the Southern States, which have abundant sunshine, an important prerequisite in odor development. Furthermore, the labor conditions in the Southern States are such that the cost of gathering, which is a serious obstacle, would be comparable to a degree with that in foreign countries

CONCLUSIONS.

In view of the success which has been achieved in the United States along a number of special lines, the outlook for a very considerable extension of the volatile-oil industry in general seems promising. Favorable conditions of soil and climate seem to be obtainable. With an increased practical knowledge of how to handle the crops of greatest promise and with a working familiarity with the

forms of apparatus used in separating the oils, the preliminary steps leading to such an extension will have been taken. Before a full-fledged industry can be expected to appear, however, much preliminary experimental work must be done over a wide area in order to ascertain the most successful combinations of soil, climate, and labor conditions.

From the standpoint of the consumption of products derived from volatile oils obtained from plants, the commercial statistics show a large and active market. They also show that the demand is now supplied in very large part from foreign sources, and an active interest in testing the possibilities of our land is suggested.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 196.

B. T. GALLOWAY, *Chief of Bureau.*

BREEDING DROUGHT-RESISTANT FORAGE PLANTS FOR THE GREAT PLAINS AREA.

BY

ARTHUR C. DILLMAN,
Assistant Physiologist, Alkali and Drought Resistant Plant-Breeding Investigations.

Issued December 17, 1910.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1910.

BUREAU OF PLANT INDUSTRY.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., August 16, 1910.

Sir: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 196 of the series of this Bureau the accompanying manuscript entitled "Breeding Drought-Resistant Forage Plants for the Great Plains Area," by Mr. Arthur C. Dillman, Assistant Physiologist in Alkali and Drought Resistant Plant-Breeding Investigations, Bureau of Plant Industry.

In the Great Plains area, where the rainfall is limited in quantity and is of uncertain distribution, drought-resistant varieties of crop plants are indispensable if farming is to be made a reasonably safe enterprise. Forage plants which can be successfully grown with a limited moisture supply are especially needed in order to build up a well-balanced type of dry-land agriculture. The Department of Agriculture has introduced from foreign countries many varieties that are more drought resistant than those ordinarily grown in the United States, but even these can be further improved and adapted by the use of plant-breeding methods.

The present paper describes the preliminary results of work along this line which was begun by the Bureau of Plant Industry in cooperation with the South Dakota Agricultural Experiment Station in 1906, and is now being carried on by the Bureau on the experiment farms at Bellefourche, S. Dak., and Akron, Colo. The progress that has been made in breeding drought-resistant and otherwise improved strains of alfalfa, amber sorgo, millets, *Bromus inermis,* and other forage plants especially adapted to the area is here reported. In several of these crops new and promising strains have been developed. As soon as a satisfactory test of their comparative drought resistance can be had, the seed of those strains which stand the test most successfully will be increased and distributed. It is believed that this bulletin will be useful, not only because it points out the scope of the work conducted by the Bureau of Plant Industry in this field, but because it describes simple breeding methods which can be applied by the farmers of the area for the improvement of their crop varieties in respect to drought resistance and other qualities.

Respectfully,

G. H. Powell,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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BREEDING DROUGHT-RESISTANT FORAGE PLANTS FOR THE GREAT PLAINS AREA.

INTRODUCTION.

This paper describes the results so far attained in breeding improved strains of alfalfa, sorgo, millet, smooth brome-grass, and other forage plants adapted to the semiarid conditions of the elevated region lying between the ninety-eighth meridian and the Rocky Mountains. While the work with none of these crop plants has reached completion, it is considered desirable to publish at this time a description of the objects, methods, and preliminary results.

In this plant-breeding work, as in all other investigations bearing upon dry-land agriculture that are carried on by the Bureau of Plant Industry, it is intended to make the results applicable to the whole territory in which similar climatic conditions exist. By conducting the work simultaneously and with the same methods at different stations, comparable results are expected. The working out of this plan should afford a much safer basis for the establishment of broad principles in drought-resistance breeding than could be attained by any strictly local work. Although the actual breeding is at present confined to only two of the dry-land stations, these are representative of a considerable portion of the Great Plains.

At both of these stations the Office of Forage-Crop Investigations is engaged in testing varieties of the forage plants that are believed to be adapted to the climatic conditions of the region. The drought-resistant plant breeding is conducted in cooperation with these variety tests, which not only afford material for the selection of resistant individuals, but give an excellent opportunity for comparing the drought resistance of the new strains developed with that of a large number of existing varieties of the same crops.

OBJECTS SOUGHT.

To make dry-land farming in a semiarid region like the Great Plains a reasonably safe enterprise, drought-resistant crops must be grown. Most of the varieties of crop plants that have heretofore been used in this region have originated in countries of abundant

rainfall, like the eastern United States and western Europe. In recent years the Department of Agriculture has introduced a large number of more or less drought-resistant crop plants from foreign countries where the climatic conditions more nearly resemble those of the Great Plains area. Even with these plants, however, preliminary tests show that there is much opportunity for breeding work to improve the quality, increase the yield, and eliminate the less hardy and less drought-resistant individuals.

Cultivated forage plants are greatly needed in the Great Plains area. Until recently this was essentially a stock-raising territory, and although large parts of it are now being divided up into small farms devoted to grains and other crops, it seems altogether likely that stock raising will continue to be one of the chief industries. In the past the chief dependence of the stock grower has been the "range;" in other words, the native growth of prairie grasses. Only scattered attempts have been made to grow cultivated forage plants, but as the region becomes more and more settled there will be an increasing demand for hay and other stock feeds to supplement the wild-grass pasturage. The growing of forage plants is likely to become one of the most important phases of Great Plains agriculture.

The chief limiting factor in the production of crops in this region is the lack of sufficient moisture. One means of meeting this deficiency is the use of tillage methods that will conserve water in the soil, preventing as far as possible loss by evaporation. Another means of attacking the problem is to grow the most drought-resistant varieties that can be obtained. The investigations described in the present bulletin are concerned with developing such varieties by breeding methods.

The principal factors that enter into drought resistance are probably the ability of the plant to develop a root system that will utilize to the utmost a scanty supply of soil moisture and its ability to reduce transpiration, or loss of water, through the leaves and stems when the air is very dry. It is evident that certain species and varieties of crop plants are better equipped in these respects than others, since they wilt less rapidly when the soil moisture is deficient and when hot, dry winds are blowing. Every farmer on the Great Plains knows that under such conditions the sorgos, kafirs, and milos, for example, will remain fresh and green longer than corn; moreover, within the limits of a single crop species there are great differences in drought resistance, some varieties being superior to others. This has been abundantly proved in the course of the variety-testing work of the Office of Grain Investigations and of the state experiment stations, which have shown certain varieties of wheat, oats, barley, etc., to be more drought resistant than others. Finally, every close observer

will notice that some individual plants of a variety are markedly more resistant than other plants from the same lot of seed growing beside them. This fact gives the plant breeder an opportunity to produce still more resistant strains of the drought-resistant varieties by the persistent selection of such individual plants.

Other qualities of the plant must not be neglected in breeding forage plants for drought resistance. The quantity and quality of the hay and seed are equally important. The individual plants which are actually most drought resistant may be deficient in yield and quality and will have to be discarded in favor of other individuals of somewhat less drought resistance but in other respects superior. Good seed production is essential not only in species that are grown primarily for the seed, but in those which are grown for hay, since in order to keep the variety drought resistant it is necessary that the seed should be produced in the region to which it is adapted. Fortunately the yield and quality of the seed are generally better in semiarid than in humid regions. This is notably the case with alfalfa, of which most of the commercial seed at present grown in the United States is produced under irrigation and consequently is not the best adapted to dry-land agriculture.

In perennial plants like alfalfa and the principal meadow grasses, hardiness or resistance to winterkilling is another essential characteristic, especially in the northern part of the Great Plains. Early maturity is of great importance in the growth of annual crops. One-half of the annual precipitation in this region occurs from April to July, inclusive. It is therefore desirable to obtain early-maturing strains which will make most of their growth during the period when the soil contains its greatest amount of moisture. In the northern part of the Great Plains the development of locally adapted varieties of sorgos, milos, and other late-maturing crops is hindered by the shortness of the season. In breeding these plants the ability to ripen seed as early as possible is a characteristic that can not be overlooked.

HISTORY OF THE INVESTIGATIONS.

The plant breeding for drought resistance described in this paper is a continuation of the work begun by Prof. W. A. Wheeler in 1904 at the Highmore substation of the South Dakota Agricultural Experiment Station. Professor Wheeler was at that time botanist of the South Dakota station. The writer was associated with him as student assistant in botany and was in close touch, almost from the beginning, with the plant-breeding work carried on under his direction. In the breeding work at Highmore all the principal forage crops of the region were taken up, alfalfa, clover, millet, sorghum, smooth brome-grass (*Bromus inermis*), western wheat-grass (*Agro-*

13.3 inches. The greater part of the rainfall in this region occurs during the early growing season, and the latter part of the summer is liable to be exceedingly dry.

Although the soil type at Bellefourche is peculiar to only a part of the region, the similarity of the climatic conditions is such that we may expect that strains of forage crops developed at this station will be adapted to the greater part of western North and South Dakota and eastern Montana.[a]

AKRON DRY-LAND STATION.

The Akron Dry-Land Station is conducted by the Office of Dry-Land Agriculture Investigations of the Bureau of Plant Industry. The farm is located about 4 miles east of Akron, Washington County, in northeastern Colorado. It was selected as a desirable place for breeding drought-resistant forage crops because of its central location in the Great Plains. The climatic conditions are probably more severe here than in the greater part of the central Great Plains, but in general the station is representative of a large part of the area. The altitude of the station is nearly 4,700 feet, being about 1,800 feet higher than the Bellefourche station. The average annual precipitation, as computed from the records at several places in eastern Colorado, is about 17 inches, though the precipitation at Akron for the past few years has slightly exceeded this.

The land at the Akron station, on which the plant-breeding nursery is located, was broken from the native sod in June, 1907, and has been under cultivation ever since. The soil may be classed as a loam, and is generally favorable for the production of crops when sufficient moisture is present. The soil is typical of the "hard lands" of the Great Plains, as distinguished from the "sand lands" of eastern Colorado, western Nebraska, and other sections of this region. The moisture equivalent of the Akron soil is about 17 per cent, which indicates that it is only medium in water-storing capacity.

ALFALFA BREEDING FOR DROUGHT RESISTANCE.

ALFALFA BREEDING AT THE BELLEFOURCHE EXPERIMENT FARM.

SEGREGATION OF STRAINS.

In the alfalfa breeding at Bellefourche, while increased drought resistance has been the principal object in view, it has been necessary also to take into consideration hardiness, seed production, and the

[a] In transferring the breeding work from Highmore to Bellefourche, the crops were placed under different conditions of soil and a slightly different climate. The soil at the Highmore substation is a glacially deposited clay loam, containing some sand. The altitude is a little less than 1,700 feet, as compared with 2,900 feet at the Bellefourche station, and the precipitation is about 17 or 18 inches annually. Highmore may be considered as located near the eastern edge of the Great Plains, while Bellefourche is representative of the more arid portion of the northern Great Plains.

yield and quality of the forage. All selections have been made with the idea of combining large forage and seed production in the same individual plant, the forage type, however, receiving first consideration. A thorough test of the yields of all strains developed is made in broadcast plats and in cultivated rows. It should be said that no proper test of drought resistance has been had in the alfalfa-breeding work up to this time. During the time the work was carried on at Highmore, from 1905 to 1907, inclusive, the annual rainfall was above the average for that station. The season of 1908 at Bellefourche was a dry one, but this was the year when the breeding work was begun there and the plants were too young to afford records of yields under dry conditions. But since the first season's growth of an alfalfa plant is a critical period in its life, and since these selections made a good growth at Bellefourche in the comparatively dry year, 1908, it would seem that they must be at least fairly drought resistant.

During the season of 1909 the precipitation was again above the average, so that no test of drought resistance was secured that year. It will therefore be necessary to retain all of the progeny rows and plats until a proper test of drought resistance is secured.

The alfalfa stocks used in the breeding work at Bellefourche consisted of selections from six strains which were grown at the Highmore (S. Dak.) substation. Two of these strains, South Dakota No. 162 and No. 164, are recommended by Prof. W. A. Wheeler in Bulletin 101 of the South Dakota Agricultural Experiment Station as the best of the stocks tested at Highmore. The twenty stocks tested there included several hardy stocks imported by the Department of Agriculture previous to the year 1905. The two best varieties, which are described on a later page of this bulletin, proved to be perfectly hardy and of good forage and seed producing ability. Four other stocks tested at Highmore, which proved fairly hardy, are also represented in the breeding plats at Bellefourche. In the following discussion each strain is designated by a letter, the selections made from each strain being numbered in consecutive order; as A–1, E–12, etc.

Strain A.—This is South Dakota No. 65. The seed was screened from a lot of durum wheat imported from Tashkend, Turkestan, in 1902, by the United States Department of Agriculture. It was planted in 1902 on a small plat, about 12 by 50 feet, at Brookings, S. Dak. This plat went through four seasons there (from the spring of 1902 to the fall of 1906), and did not suffer any from winterkilling.

"Seed from this plat [harvested in 1904] was planted at the Highmore substation, in 1905, in a selection row. A few of the plants in this row died during the winter of 1905–6, showing that it is not perfectly hardy under severe test."[a] The plants now growing at Belle-

[a] Wheeler, W. A. Bulletin 101, South Dakota Agricultural Experiment Station, p. 135.

fourche represent the fourth generation of seed. They are somewh coarse, with stems inclined to be stout and not greatly branch The results obtained this season indicate that this strain is fair seed production.

Strain B.—This is South Dakota No. 66. "The seed was obtain by Prof. N. E. Hansen, from Merke (lat. 43° N., long. 73° E.), nor ern Turkestan in 1898 for the United States Department of Agric ture. It was distributed by the department as S. P. I.[a] No. 11 It was sown in a small plat at Brookings in 1899 and has not wint killed to date. The seed from this plat was sown at Highmore 1905 in selection rows. The results seem to show it to be about equ to No. 65 in quality, hardiness, and seed production."[b] The plan of this variety are large, coarse, woody in texture, and poor in amou of branching. It has proved the poorest in seed yield of any of t varieties tested at Bellefourche.

Strain C.—This is South Dakota No. 67. "The seed was obtain from the Minnesota experiment station as Minnesota No. 3 in 1902." Minnesota No. 3 was derived from seed purchased by the Minneso experiment station from a commercial seed firm under the name "Grimm" alfalfa, but has shown itself to be different from th variety in hardiness and other qualities. It is similar in type of pla to strain E described below, but is somewhat inferior in both fora and seed yield.

Strain D.—This is South Dakota No. 150, purchased from a see firm as Turkestan alfalfa. It is similar in type of plant to the oth Turkestan strains, which are inclined to be woody, spreading, an lacking in leafiness and branching.

Strain E.—This is South Dakota No. 162. This strain origina from the Grimm alfalfa which has been grown near Excelsior, Mi for more than fifty years.[c] In all the tests at Brookings, Highm and Bellefourche it has proved superior to all other stocks teste seed production, hardiness, and forage type of plant. The se tions grown at Bellefourche are inclined to be very leafy, m branched, with short internodes and fine stems. This gives maximum amount of palatable forage. The selections have pro to be uniformly good in seed production, which is a valuable ch acteristic of these selections, since the seed yield is one of the imp tant features of the crop in the Great Plains region.

[a] An abbreviation for the Office of Foreign Seed and Plant Introduction of the Un States Department of Agriculture.

[b] Wheeler, W. A., loc. cit.

[c] Brand, C. J. The Acclimatization of an Alfalfa Variety in Minnesota. Sci vol. 28, 1908, p. 891. Westgate, J. M. Bulletin 169, Bureau of Plant Indu U. S. Dept. of Agriculture, 1909. Science, vol. 30, 1909, p. 184.

Strain F.—This is South Dakota No. 164, which is thought to be S. P. I. No. 991, a Turkestan stock. This strain is less coarse and is better in quality of forage than most of the Turkestan varieties. In amount of seed produced it stands second to strain E, as noted in Table I.

A part of the selections with which the breeding work was begun at Bellefourche were made in 1907 by Mr. John Cole, now of the Office of Dry-Land Agriculture Investigations of the United States Department of Agriculture, but at that time connected with the South Dakota Agricultural Experiment Station and in charge of the Highmore substation. These are selections A 1 and 2, B 1, C 1–4, D 1 and 2, E 1–7, and F 1–3. Selections E 9–16 and F 4–12 were made at the Highmore substation in 1906 by Prof. W. A. Wheeler. Selections E 17–31 and many other selections not described in this bulletin were made by the writer.

BREEDING METHODS USED.

In the alfalfa-breeding nursery (Pl. I, fig. 1) plants are grown singly in hills 21 inches apart, the rows being 42 inches apart. This allows 75 plants to a row in the regular plats of the station, which are 8 rods long. The seed from a single plant is generally planted in one row of hills, but when sufficient seed was available, two rows of hills have been planted to a single selection, and when the quantity of seed available was small, less than a full row has been planted to a selection. Where less than a row was planted there were 25 or 50 hills instead of 75, as in a full row. The hills are planted at definite distances apart so that the rows of plants are in line in both directions. (See Pl. I, fig. 1.) Each row is given a progeny number and each plant within the row an individual number corresponding to the number of the hill in which the plant grows. If a plant is missing in the row the order of numbering is not changed, each plant in the row being permanently designated by the position it actually occupies. This system makes a convenient and certain means of designating each plant and obviates the use of stakes except at the head of the row.

At the period when the first blossoms appear the plants in the nursery are studied carefully and complete notes are taken as to the type of plant, the amount of branching, leafiness, and the color of the flowers. The forage type of plant is best judged at this time, for it is at this stage in the development of the plant that it should be cut for forage. After these notes are taken all the inferior plants, together with such as are divergent from the type of the row, are cut and removed from the nursery. This is done in order that the pollen from these inferior plants will not be carried to and fertilize the flowers of the superior plants. It may be explained further that all plants at the ends of the rows are discarded. This is done in order to

secure comparable results of yields per plant from each progeny row, as the end plants, because of their favored position, make a larger growth. The purpose is to secure accurate comparative yields of all the progeny rows.

Later in the season, when the seed is ripe, the superior individuals are selected as mother plants to furnish seed for planting the following season and thus continue the work of selection.[a]

After the superior plants have been selected the bulk of the plants in the row are harvested, dried in shocks, weighed, and thrashed. Since a record is kept of the number of plants harvested, an accurate estimate of the producing power per plant of each row is easily made. The yields of the progenies grown at Bellefourche during the season of 1909, which are in the fourth generation of selection, are presented in Table I.

UNIFORMITY OF PLANTS IN THE PROGENY ROWS.

Breeding work with a plant like alfalfa has the special advantage that one is able to compare living plants belonging to different generations of selection. Alfalfa being perennial, the mother plants can be retained in their original places in the breeding nursery for comparison with their progeny. Thus, the degree in which the progeny has inherited the desirable characters of the mother plant can be checked by direct comparison. In general, there has been great uniformity in the rows although they are the progeny of plants that were selected without any precaution to insure close pollination. As shown in Table I, in 29 out of 36 progeny rows harvested separately, in which the plants "off type" were discarded, over 80 per cent of the plants in each row were harvested as uniform in type. Some prominent types may be noted, as E-2, in which the plants were very erect, rather slender, and only moderately branched, and had dark-purple flowers. This is a rather distinct, easily recognizable form and it will be noted that 84 per cent of the plants in this row conformed to the type. B-1 is another distinct type; the plants are tall, coarse, slightly branched, and woody, with very light purple flowers fading to white. Of the plants in this row 92 per cent were typical. In some progeny rows the variation in type of plant has been great, but in general the uniformity is close enough to show that this method of simple selection without isolation can give valuable results in breeding alfalfa.

[a] Heretofore the plants have not been inclosed with screens to insure self-pollination; but it is the plan in future work to inclose a number of plants and pollinate them by hand and thus get a comparison of the uniformity of progeny of screened plants and those which are exposed in the normal way to the chance of cross-pollination by insects. These screens will be placed over the plants at the beginning of the blossoming period. Hitherto the only distinction made with superior plants has been to harvest them separately at the time the seed matured.

COMPARATIVE YIELDS[a] OF THE DIFFERENT STRAINS AND PROGENIES.

TABLE I.—*Uniformity and seed yield of plants of alfalfa grown in progeny rows at Belle-fourche, S. Dak., in 1909.*

Strain.	Progeny No.	Proportion of typical plants in progeny rows.	Average dry weight per plant.	Average seed yield per plant.	Seed yield per 100 grams of dry plant.
		Per cent.	*Grams.*	*Grams.*	*Grams.*
A	1	91	138	21	15.2
	2	88	129	16	12.4
B	1	92	153	12	7.8
C	1	82	150	14	9.3
	2	81	150	21	14.0
	3	79	135	16	11.9
	4	85	132	20	15.1
D	1	89	138	13	9.4
	2	85	123	17	13.8
E	1	79	171	27	15.8
	2	84	171	18	10.5
	3	72	....	23	....
	4	88	189	33	17.5
	5	80	144	23	16.0
	6	82	192	32	16.7
	7	80	150	25	16.7
	9	91	150	22	14.7
	10	90	138	22	16.0
	12	100	150	21	14.0
	13	95	138	19	13.8
	15	74	180	27	15.0
	16	83	....	28	....
	17	85	138	20	14.5
	18	66	165	28	17.0
	19	84	180	33	18.3
F	1	85	144	18	12.5
	2	76	150	20	13.3
	3	81	150	19	12.7
	5	87	135	14	10.4
	6	87	132	15	11.4
	7	91	134	22	16.4
	8	83	192	28	14.6
	9	57	144	17	11.8
	10	85	....	21	....
	11	82	144	20	13.9
	12	91	180	30	16.7

The results given in Table I were obtained from a large number of plants. Where the progeny occupied two rows of the breeding nursery the number of plants harvested in the bulk lot exceeded 100. Where the progeny occupied one row the number of plants usually exceeded 50, but where less than a row was planted the report shows the yield of only 20 to 50 plants. Yields estimated on more than 50 plants should represent fairly the producing power of the progeny under this system of planting. Column 3 of Table I shows the percentage of plants of uniform type in the progeny row, leaving out of consideration the inferior plants which were discarded early in the season.

The dry weight of the plants and the seed yield have been reduced to an average per plant so as to afford a comparison of the producing

[a] The yields obtained in the breeding nursery, where each plant has much more space than in ordinary field culture, do not necessarily indicate that under field conditions the different strains will be found to occupy the same relation to each other in comparative yielding power.

power of the progeny. Column 6 of the table gives the seed yield per 100 grams weight of plant, showing the relation between the seed yield and forage production in each progeny row. It will be seen that a large seed yield is usually associated with a large forage yield, as is shown by a comparison of columns 4 and 5. This result throws some light upon the question whether or not heavy seed production and heavy forage production are opposed, or whether they can be combined in the same individual; the results seem to indicate that these two characteristics can be combined. This purpose has, in fact, been constantly kept in mind in the selection of the mother plants.

Table II is inserted to show the comparative yields of the strains represented in the breeding work. It will be seen that strain E exceeds all others in both seed yield and forage production, as shown by the yield per plant, and that large seed yield and heavy forage production can be combined in the same strain.

TABLE II.—*Proportion of plants winterkilled and average yield of each strain represented in the alfalfa-breeding nursery at Bellefourche, S. Dak., in 1909.*

Strain.	Variety from which derived.	Winter-killing, 1908-9.	Total number of plants harvested.	Average dry weight per plant.	Average seed yield per plant.
		Per cent.		*Grams.*	*Grams.*
A	Turkestan		182	147	18
B	Do	2	132	153	12
C	Grimm		281	141	18
D	Commercial Turkestan		121	132	14
E	Grimm	4	601	162	24
F	Turkestan	1	354	150	21

WINTERKILLING.

The winterkilling of the varieties in the breeding nursery during the winter of 1908–9 was practically negligible, while the broadcast plats and cultivated rows of the same varieties did not show any killing at all. The nursery method of planting, where each plant stands alone and unprotected, is the most severe test of hardiness. At the Ashcroft (S. Dak.) Weather Bureau station, where conditions are probably most nearly representative of the Bellefourche Experiment Farm, a temperature of −30° F. was recorded in January, 1909.

It should be said that the varieties of alfalfa represented in the breeding plats at the Bellefourche Experiment Farm have been subjected to severe winterkilling tests for several generations. They represent selections, some of three and some of four generations of individual plants grown in the breeding nursery at Highmore under conditions which eliminated the less hardy individuals. The minimum temperatures recorded during the time the work was carried on at the Highmore substation are as follows: 1904, −27° F.; 1905, −36° F.; 1906, −31° F.; 1907, −27° F. There was some winter-

killing during each of these winters, especially in the breeding nursery, where the test is most severe. The winter of 1905–6 was especially severe; among 20 stocks tested at Highmore, 8 winterkilled greatly and were discarded. Some winterkilling was noted in all the varieties except South Dakota No. 162, which is strain E of the above table

FUTURE TESTING OF STRAINS.

The bulk seed from each of the best progeny rows was planted in 1910 under two conditions, in cultivated rows (Pl. I, fig. 2) and in broadcast plats. If conditions favor a test, the comparative drought resistance of the different strains, progenies, and individual plants will be carefully noted. At the beginning of the season a record of their hardiness and earliness of development was made. Later in the season comparisons of yields will be made from the broadcast plats as to forage production and from the cultivated rows as to seed production. If the progenies which have proved superior thus far continue to show superiority in these characters, combined with hardiness and drought resistance, seed from them will be increased and distributed as soon as possible.

ALFALFA BREEDING AT THE AKRON DRY-LAND STATION.

The plan followed at Bellefourche in the alfalfa-breeding work has been followed at the Akron Dry-Land Station. There is not likely to be so severe a test of hardiness or resistance to winterkilling at Akron as farther north in the Great Plains. The test of drought resistance, however, is likely to be quite as thorough.

The strains of alfalfa are the same as those used at the Bellefourche Experiment Farm. The plan has been to divide the seed of the selections made at Bellefourche and from other sources and plant part of the seed at Bellefourche and part at Akron. In this way a comparison of the effect of somewhat different climatic and soil conditions can be made and the possibility of obtaining an adequate test of drought resistance is increased. As the breeding nursery was established in 1909, no results have yet been obtained except notes on the season's growth and the autumn stand of each progeny row.

SEED PRODUCTION OF ALFALFA PLANTED IN HILLS.

Maximum seed production in alfalfa can no doubt be attained by growing plants in such a manner as to allow cultivation of the soil rather than by planting in broadcast plats. The method of planting in single or double cultivated rows has been recommended[a] and is unquestionably an improvement over the broadcast method for seed production. The results as to seed production in the breeding nursery

[a] Brand, C. J., and Westgate, J. M. Circular 24, Bureau of Plant Industry, U. S. Dept. of Agriculture.

at Bellefourche suggest that the method of planting in hills is still more favorable to seed production and may be used to good advantage where it is desired to increase rapidly the seed of some valuable strain. It was observed that the yield of seed in the breeding plats at the Highmore substation was often fairly good when the broadcast plats yielded little or no seed. In 1907 a commercial seed firm in South Dakota, with which the writer was then associated, obtained a yield at the rate of 200 pounds of seed per acre in the alfalfa-breeding nursery of half an acre. The plants were grown singly 18 inches apart, in rows 36 inches apart. In the breeding nursery at Bellefourche in 1909 the yield of seed was much greater than from alfalfa seeded in broadcast plats or in double-cultivated rows. These yields are presented in Table III.

TABLE III.—*Seed yield of alfalfa planted in hills compared with broadcast or row planting.*

Plat No.	Method of planting and variety.	Seed yield obtained on $\frac{1}{10}$-acre plat.	Yield per acre.	Yield estimated on perfect stand.
		Pounds.	*Pounds.*	*Pounds.*
67	Breeding nursery, 475 plants, strains D and F, in hills	20	200	348
69	Breeding nursery, 500 plants, strain E, in hills	26	260	439
61	Broadcast plat, strain of Grimm alfalfa	12	120	
62	Double-cultivated rows, strain of Grimm alfalfa	$8\frac{1}{2}$	85	

In plat 67, 325 plants, and in plat 69, 350 plants, were discarded or missing. The missing plants had been destroyed chiefly by pocket gophers. In estimating yields the living plants nearest these were discarded as having had an unduly favorable opportunity. For this reason column 4 is added, estimating the yield per acre of a perfect stand in the breeding nursery, which would be 825 plants on the $\frac{1}{10}$-acre plat.

The method of planting in hills or very thinly in single rows can be recommended only where rapid increase of seed is desired, as when some especially valuable selection is grown. With the present interest in alfalfa breeding and the great need for drought-resistant and hardy strains, the price of seed of superior strains is likely to be high. Under such conditions the above method of seed increase may be used to advantage.

BREEDING DROUGHT-RESISTANT SORGOS.

CONDITIONS TO BE MET.

Sorgo is an important forage crop in the central and southern Great Plains, but its use in the northern part of the region has been limited because the season is too short to allow the crop to mature seed. Sorgo is not likely to be planted extensively in regions where seed can not be matured. To purchase seed every year often makes the crop unprofitable. Further than this, the greatest food value of the crop

can not be secured unless it reaches the point of flowering at the time of harvesting. The purpose in the breeding work described here has been to obtain a drought-resistant and productive strain which will mature early. Such a strain would extend the sorgo-growing area north of its present limits.

The breeding work with sorgo at Highmore and Bellefourche has been done with a saccharine sorghum of the Minnesota Amber type, South Dakota No. 341. This strain has slender stalks and rather long, narrow leaves. The plants stool quite freely, having from two to six suckers per plant. The seed panicles become open and spreading as the seed ripens. The seeds are reddish yellow in color when separated from the glumes. The glumes, however, are black and either smooth or slightly hairy. In thrashing, many of the seeds separate from the glumes. The stock of this variety was found at the Highmore substation in 1903 under the name of "Montana." This is all that is known about its history. It was grown at Highmore in 1906 in comparison with two other amber types and proved to be two weeks earlier than the varieties with which it was compared. The earliness of the type has made it valuable as a stock from which to work. Two valuable selections (Pl. II, fig. 1) were made in the course of the breeding work at Highmore, and seed of these has been increased and is now on the market.

The two selections referred to were very marked in point of earliness and in uniformity of the progeny. It is probable that the early flowering of the mother plant in each of these selections prevented cross-pollination from any of the surrounding plants, which were ten days or more later in flowering. This insured self-fertilization and the resulting uniformity of progeny.

Yields of sorgo, South Dakota No. 341, at the Highmore substation for three seasons, 1906 to 1908, inclusive, and at the Bellefourche station for 1908 and 1909, were furnished by the Office of Dry-Land Agriculture Investigations. These yields are from each of two $\frac{1}{10}$-acre plats used in the rotation experiments of that office and are as follows:

TABLE IV.—*Yield per acre of air-dry fodder at Highmore and Bellefourche, S. Dak.*

Place and year.	Yield of rotation No. 33.	Yield of rotation No. 34.	Average yield.
Highmore:	*Pounds.*	*Pounds.*	*Pounds.*
1906	11,140	10,810	10,975
1907 [a]	4,940	5,760	5,350
1908	8,150	7,250	7,700
Bellefourche: [b]			
1908	2,330	4,200	3,265
1909	4,280	7,560	5,920
Average per acre of all plats			6,642

[a] The low yields in 1907 at Highmore were due to a poor stand of plants in both plats.
[b] The lower yields in rotation No. 33 than in No. 34 at Bellefourche for both years, 1908 and 1909, are due to the poorer type of soil where the plats of rotation No. 33 were located. The soil there is very poor in spots, being liable to puddling and to extreme baking when dry.

The average yield of 6,642 pounds of feed per acre at these two stations is sufficient to warrant the growing of this strain where forage of this kind is desired.

SORGO BREEDING AT THE BELLEFOURCHE EXPERIMENT FARM.

In 1908 the writer obtained some of the bulk seed of the South Dakota No. 341 stock from the Highmore substation and planted a field with it at Bellefourche for the purpose of making selections. In September, 1908, 18 individual selections were made in this field. These were selected for earliness, amount of stooling, and uniformity of the main stalk and suckers in height and ripening. The selections ranged in date of ripening from September 10 to September 20, in height from 4½ to 5½ feet, in yield of seed from 50 to 100 grams, and in number of suckers from 3 to 5 per plant. The characters which make the most desirable type of forage sorgo are slender stems, uniformity in the size of the suckers on each plant, and large total leaf surface, and these points governed the selection.

The seed of each of these selected plants was planted in a single row, 8 rods long, in 1909. In date of ripening the progeny rows were very similar to the mother plants, ranging from September 10 to September 18. In height the progenies exceeded the respective mother plants by about 6 inches, the plants ranging from 5 to 6 feet high. This was probably due to the more favorable season in 1909. Each individual row was quite uniform as to height and type. (Pl. II, fig. 2.)

In order to show what characters apart from drought resistance are regarded as most important in a sorgo for the northern Great Plains and to give some idea of the amount of diversity still remaining in this selected stock, short descriptions are given of the types that predominated in the 1909 progenies of the five most promising selections. It is possible that strains derived from more than one of these selections may ultimately be found valuable for this region. Thus, near the northern limit for sorgo culture the earliest maturing strain, even if somewhat inferior in other respects, may prove to be the most useful, while farther south a later developing strain which produces a better quality of forage may be preferred.

Selection No. 2.—Plants in this row stooled freely; the stalks were small and fine and there were many small suckers which would make forage of good quality. The progeny was good in seed production and uniform in early ripening. This was one of the best rows.

Selection No. 6.—This was a good row, but was slightly later than that of selection No. 2 in ripening seed. It was very uniform in height and type of plant. The plants were very leafy and had numerous suckers that were slender and fine.

Selection No. 9.—This was about the best row in the breeding plat; the plants stooled freely, the stalks were small, and the plants uniform in height and type. It was early and uniform in ripening seed.

Selection No. 10.—This row was very similar to that of selection No. 9 except that the plants were later in maturing and the stalks were slightly thicker. (See Pl. II, fig. 2.)

Selection No. 12.—This was a fairly good row; the stalks were small and the plants stooled freely and were early in ripening. A peculiarity of this row was that a large percentage of the outer glumes of the seed were free from hairs.

Bulk seed was saved from each of the above selections. This seed was harvested September 16, when nearly all the plants in the breeding nursery were mature. Seed from each row was harvested separately by cutting the mature panicles from all the plants that showed the type characteristic of the row. No comparisons of yields of either seed or forage were made, as the differences in stand in the different rows would have made the comparison of little value. The bulk seed from each row was planted in field plats in 1910 for comparison of their drought resistance, yield, uniformity, earliness, and other characteristics. The writer believes that sorgo can be made a valuable crop in the northern sections of the Great Plains if this early-maturing type is planted. Since no strain that will ripen seed is at present generally grown in this region, it would seem desirable to increase seed of these superior selections as rapidly as possible for distribution to farmers.

SORGO BREEDING AT THE AKRON DRY-LAND STATION.

Seed of each of the selections made at Bellefourche in 1908 was planted in single rows 8 rods long at the Akron Dry-Land Station in 1909. Each of the plants selected in 1908 bore two or more panicles of mature seed. The seed from one of these panicles was planted at Bellefourche and the seed from the other at Akron. The progeny was very similar in type of plant and general characteristics to that grown at the two stations, but it is evident that extreme earliness in ripening is not of first importance at the Akron station. The progeny of selection No. 13 was considered the best row there, while at Bellefourche it was decidedly too late in maturing and the stalks had a tendency to be coarse and pithy. This row, No. 13, was harvested for seed, and the seed was planted for comparison with other varieties in 1910.

It is probable that later maturing varieties (for example, Orange and Red Amber) may be grown to good advantage at Akron, and in future drought-resistance breeding work at that locality such varieties will be considered.

BREEDING DROUGHT-RESISTANT MILLETS.

SEGREGATION OF STRAINS.

Several varieties of foxtail millets (*Chaetochloa italica*) are grown rather extensively in the northern Great Plains. This crop is especially valuable there because it requires only a few weeks to complete its development; for this reason it is often used as a "catch crop" to replace other crops which have been frozen or otherwise destroyed in early summer.

Most of the varieties now on the market are mixtures of more or less distinct types and offer an excellent opportunity to the plant breeder to segregate these types and develop pure strains. This has been the purpose of the work here described, special attention being given to the segregation of strains characterized by drought resistance, early maturity, and maximum forage yield.

RESULTS OF PRELIMINARY WORK AT THE HIGHMORE SUBSTATION.

Mention is made in Bulletin 101 of the South Dakota Agricultural Experiment Station of the breeding work with foxtail millets carried on in cooperation with the Bureau of Plant Industry at the Highmore substation. The breeding work was conducted with five varieties of millet—Kursk, Common, Siberian, Hungarian, and German. Several uniform and productive strains were developed at Highmore and were grown for comparison of yields, but the results have not been published in detail. Seed of one pure strain of Kursk millet developed at Highmore has been increased by a commercial seed firm and is now offered for sale. The Office of Forage-Crop Investigations of the Bureau of Plant Industry secured some of this seed in 1907, and it was distributed under S. P. I. No. 22420.

VARIETY TESTS AT THE BELLEFOURCHE EXPERIMENT FARM.

In 1908 breeding work was begun at the Bellefourche Experiment Farm with five varieties of foxtail millet (*Chaetochloa italica*). In cooperation with the Office of Forage-Crop Investigations a preliminary test was made in 1908 of these varieties in $\frac{1}{20}$-acre plats and in 1909 in $\frac{1}{10}$-acre plats. The results were as follows:

TABLE V.—*Yield per acre of five varieties of foxtail millet at Bellefourche, S. Dak., in 1908 and 1909.*

Variety.	Yield of hay from plat.	Estimated yield of hay per acre.
Plats of one-twentieth acre, 1908:	*Pounds.*	*Pounds.*
S. P. I. No. 22420, Kursk	144	2,880
S. P. I. No. 22423, Common	150	3,000
S. P. I. No. 22340, German	116	2,320
S. P. I. No. 22424, Siberian	150	3,000
S. P. I. No. 22426, Hungarian	130	2,260
Plats of one-tenth acre, 1909:		
S. P. I. No. 25220, Kursk	154	1,540
S. P. I. No. 24841, Common	206	2,060
S. P. I. No. 24842, German	68	680
S. P. I. No. 24843, Siberian	194	1,940
Average yield for the two years of the three best millet varieties:		
Common	....	2,530
Siberian	....	2,470
Kursk	....	2,210

About thirty other species and varieties were tested in single rows in 1908, but none of these proved to be of any special value for this region except S. P. I. No. 20694. Seed of this number was obtained by Professor Hansen, at Khokand, Russian Turkestan, in 1906, when acting as agricultural explorer for the Department of Agriculture. A quantity of the seed was planted in a selection row at Bellefourche in 1908. Two plants in this row matured seed and were saved. Since the plants were identical, so far as could be seen, the seed from the two was mixed and planted in a progeny row in 1909. The selection is of good forage type, but the panicle is open and the seed shatters readily.

MILLET BREEDING AT THE BELLEFOURCHE EXPERIMENT FARM.

BREEDING METHODS.

The methods used in the millet-breeding nursery were much the same as in the alfalfa nursery. In 1908 the seed of each of the varieties, Kursk, Common, German, Hungarian, and Siberian, was planted in hills 8 inches apart, in rows 42 inches apart (Pl. III, fig. 1). The seedlings were thinned to single plants in a hill. Selections of the superior individual plants were made and the seed planted in single rows 8 rods long, in 1909 (Pl. III, fig. 2).

RESULTS OF THE WORK.

The table following gives the record of yields and other data concerning the individual plant selections made in 1908 the progeny of which gave the largest yield in 1909:

TABLE VI.—*Yield of millet selections of 1908 and of their progenies grown at Bellefourche, S. Dak., in 1909.*

Variety and selection.	Number of selections in 1908 and of progeny rows in 1909.	Individual selections of 1908.			Progeny grown in 1909.[a]		
		Total dry weight of plant.	Weight of seed.	Proportion of seed to 100 parts of straw.	Total dry weight of plants.	Weight of seed.	Proportion of seed to 100 parts of straw.
		Grams.	*Grams.*	*Per cent.*	*Pounds.*	*Pounds.*	*Per cent.*
Kursk, No. 22420:[b]							
1	....	100	29	40	28	9¼	51
2	....	125	43	52	29½	9½	48
4	....	85	16	23	29	9	45
5	....	130	27	26	30	8¼	41
8	....	120	19	19	28	8¼	43
10	....	130	29	29	27	8¾	48
11	....	150	22	17	27	8	42
Common, No. 22423:[b]							
1	....	112	42	60	21	7¾	58
4	....	95	33	53	18¾	7¼	62
7	....	100	38	61	19	8	73
8	....	65	28	76	22½	8½	60
Siberian, No. 22424:[b]							
1	....	120	25	26	22½	7	45
5	....	95	8	9	23	6¾	41
9	....	140	16	13	21½	5	30
10	....	95	13	16	23	5¼	31
Hungarian, No. 22426:[b]							
1	....	170	15	10	30½	3	11
3	....	170	13	8	28	4½	19
7	....	127	19	17	26½	5¾	28
8	....	120	12	11	25	4½	22
S. P. I., No. 20694:							
1	....	55	5	10	26	5½	27
2	....	90	7	8	....	....	....

AVERAGE YIELDS OF ALL THE SELECTIONS AND PROGENIES.[c]

Kursk, No. 22420	15	108	23	27	27	8½	47
Common, No. 22423	8	86	31	56	18	7½	63
Siberian, No. 22424	10	122	16	15	21	5½	35
Hungarian, No. 22426	8	130	13	11	25	4½	24

[a] The yields of the different progenies are strictly comparable because the rows were of uniform length and the stands were all perfect.

[b] Only those selections from each variety are here included of which the progenies in 1909 gave yields of seed and of total dry matter above the average for the progenies of all the selections made in 1908 of that particular variety.

[c] Including selections the progenies of which yielded low in 1909 and were hence excluded from the preceding showing.

Some interesting results are shown in the millet-breeding work as recorded in the above table. It will be noted in the record of averages that the Kursk is the highest yielding variety in the progeny rows grown in 1909, both in total weight of plant and weight of seed. Kursk is considerably ahead of any other variety in yield of seed though the Common variety exceeds it in proportion of seed to straw.

It will also be noted that the yields of seed and straw of the progenies, in general, correspond rather closely with those of the respective mother plants. This is especially marked in the Kursk and Common varieties. For example, in the Kursk variety, seven selections are separately listed in which the progeny of each yielded above the average of all rows. As shown in Table VI, the selected mother plants all yielded

above the average in total weight of plant, except No. 1 and No. 4. Selections 6, 7, 9, 12, 14, and 15 (not separately shown in the table) yielded below the average of both mother plants and progeny.

DATES OF RIPENING.

The average dates of ripening and the average number of days from date of planting to maturity for the selected varieties for the two years were about as follows:

TABLE VII.—*Date of ripening and length of growing period of several selected varieties of millet at Bellefourche, S. Dak.*

Variety.	Date of ripening.	Maturing period. (days)
Common	August 24	96
Kursk	August 28	100
Hungarian	September 7	110
Siberian and No. 20694	September 10	113

It will be seen that the Common and Kursk varieties are earlier by ten days or more than the Hungarian and Siberian. Earliness in ripening is an important factor in all dry-land crops, especially millet, which is often used as a catch crop to replace a previously destroyed crop.

UNIFORMITY IN THE PROGENY ROWS.

It was noted in the breeding plats that the progeny rows from the different selections of Kursk resembled one another much more closely than the progeny rows from any other variety. This may be accounted for by the fact that the bulk seed from which these Kursk selections were made was itself the product of two selections made at Highmore only three or four generations back. There seems also to be great uniformity among the plants in each progeny row.

The selected plants have been remarkably true to seed from the beginning, indicating that millet is probably a self-pollinated plant. This belief is based on the general uniformity of the plants in the progeny rows as observed by the writer in all his breeding work with this crop.

MILLET BREEDING AT THE AKRON DRY-LAND STATION.

Seed of several selections of millet made at the Bellefourche Experiment Farm in 1908 was used for beginning the breeding work at the Akron Dry-Land Station in 1909. These selections were the same as those planted at Bellefourche, sufficient seed being borne by each plant for use at both stations.

TABLE VIII.—*Yield of millet selections of 1908 and of their progenies grown at Akron, Colo., in 1909.*

Variety and selection.	Individual plant selections made at Bellefourche in 1908. Total dry weight of plant.	Weight of seed.	Proportion of seed to 100 parts of straw.	Progeny grown at Akron in 1909. Yields from actual stands. Total dry weight of plants.	Weight of seed.	Proportion of seed to 100 parts of straw.	Stand in row.	Total dry weight calculated to a full stand.[a]
Kursk, No. 22420:	*Grams.*	*Grams.*	*Per cent.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*	*Pounds.*
1	100	29	40	18¾	7½	63	80	23.2
2	125	43	52	39	18	86	95	41.0
3	150	25	20	33½	14¾	79	100	33.5
5	130	27	26	42	17	68	100	42.0
10	130	29	29	33¾	14½	73	100	33.7
13	145	30	26	39½	17½	80	100	30.5
15	100	29	42	28½	12	73	90	31.6
Average	126	30	34	33	14½	75	....	34.9
Common, No. 22423:								
1	112	42	60	22½	10½	87	80	28.0
2	82	40	95	13¾	4½	45	75	18.3
3	75	33	79	19½	6½	47	70	28.0
4	95	33	53	27¾	13½	98	95	29.0
7	100	38	61	19¾	9	88	95	20.3
8	65	28	76	24¾	12	98	95	25.6
Average	88	36	71	21	9	77	....	24.8
Siberian, No. 22424:								
1	120	25	26	15½	6½	68	80	19.4
4	175	25	17	37	15½	72	90	41.0
Average	147½	25	21½	26	10.9	70	....	30.2

[a] This calculation is doubtless too favorable to the rows in which the stand was incomplete, since the plants growing near the gaps unquestionably yielded more heavily than would the average plant in a row in which the stand is complete.

The yields of millets in the progeny rows in 1909 were considerably heavier at Akron than at Bellefourche. This fact is not only apparent by comparison of the average yields of all the progenies of each variety at Bellefourche (Table VI) and at Akron (Table VIII), but generally holds good in the case of progenies of those individual selections of which the seed was divided and planted partly at Bellefourche and partly at Akron. The heavier yields at Akron were doubtless largely due to the more favorable season at that locality in 1909. The rainfall there was well distributed throughout the growing season, while at Bellefourche there was less than 3 inches of rain during July and August, which is the critical period in the growth of millet. It was noted that the yield of seed in many of the rows at Akron was remarkably high. The average seed yield of the Kursk progeny rows was 14½ pounds per row, which is equivalent to a yield of 25 bushels per acre. The largest yield, from Kursk selection No. 2, of 18 pounds to the row, is at the rate of 32 bushels per acre.

As shown by the averages for the progenies of each variety, the Kursk is first in total weight of plant and weight of seed. The

superior yield of Kursk millet when grown in cultivated rows is a marked character of the variety. This is no doubt partly due to its strong stooling habit and vigorous growth. It has been noted by the writer that in seeding millets broadcast a much heavier stand is secured in the Kursk variety than in others when the same amount of seed is used per unit area. This makes it desirable to seed somewhat less of this per acre than of other varieties, especially under dry-land conditions.

In 1910 the seed of the best progeny rows grown in 1909 were planted in $\frac{1}{10}$-acre plats in comparison with standard varieties. These tests will be continued until the forage value of the different selections as compared with one another and with other varieties under conditions of severe drought can be ascertained.

BROME-GRASS.

Smooth or Hungarian brome-grass (*Bromus inermis*) is one of the most drought-resistant grasses grown in the northern Great Plains. It is well adapted to cultivation on account of its abundant seed production and vigorous habit of growth, and it has come into general favor in the Central Northwest since its introduction into the United States.[a] Several stocks of seed were tested at the Highmore substation previous to and during the time cooperation was carried on between the Bureau of Plant Industry and the South Dakota Agricultural Experiment Station. One of these stocks, listed as South Dakota No. 26, appeared to be decidedly superior to the others in forage production. This strain is rather distinct in type of plant and has light-colored outer glumes or scales around the seeds which give the mature panicle an exceptionally light-colored appearance. The plants are strong and vigorous and remain productive for several years; that is, the strain does not "run out" quickly. Bulk seed of this strain was planted broadcast and in double-cultivated rows at the Bellefourche Experiment Farm in 1909. A breeding nursery occupying two $\frac{1}{10}$-acre plats was also planted. The seed was planted in hills 42 inches apart each way and the hills were thinned to individual plants in early summer. An excellent stand was secured in all the plats. There is great diversity in the manner of growth of the individual plants in the breeding nursery. Many of them are erect and close growing, while others are inclined to spread greatly by rootstocks. There is also great diversity as to amount of leafiness and amount of stooling. Altogether there is great opportunity for selection of superior types. In addition to the work in the breeding nursery tests are being made of several individual selections of *Bromus inermis* furnished by the Office of Forage-Crop Investigations. These are planted in progeny rows.

[a] For a chemical analysis of brome-grass, see Table IX.

WESTERN WHEAT-GRASS.

Western wheat-grass, botanically known as *Agropyron smithii* (*A. occidentale*), is native over a large part of the northern Great Plains and is valued highly as a pasture and hay grass. It is especially common on the "gumbo" soils in western South Dakota. Along the river and creek bottoms, where subject to annual overflow, it forms a dense, vigorous growth and is the most valuable native hay grass of the region. In such places it forms a pure growth unmixed with other grasses. On the dry ranges it forms a considerable part of the native forage and is remarkably drought resistant. The growth on the ranges, however, is scattered and thin. In depressed areas where drainage is poor or which receive the drainage from higher areas the wheat-grass occurs to the exclusion of other native grasses. This is doubtless due partly to its great alkali resistance and partly to its ability to endure rather long periods of flooding. The alkali content of the soil in these areas ranges as high as 0.4 to 0.6 of 1 per cent.

Wheat-grass hay is locally in great demand in South Dakota. It is especially valuable for feeding to livery and other horses doing hard work. For this purpose it sells for $4 to $5 more per ton than alfalfa and mixed hay at Bellefourche, Deadwood, and other places in the Black Hills.

Chemical analyses indicate that it is especially rich in crude protein and ether extracts. The following analyses of some common native and cultivated forage plants of South Dakota are here given for purposes of comparison:

TABLE IX.—*Chemical analyses of some common native and cultivated forage plants of South Dakota.*

Name of forage plant.	Name of analyst.	Ash.	Ether extract.	Crude fiber.	Crude protein.	Nitrogen-free extract.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Western wheat-grass (*Agropyron occidentale*).	Shepard [a]	8.52	2.91	34.90	9.80	43.88
	Knight and Kepner.[b]	5.03	3.07	36.70	9.23	45.97
Slender wheat-grass (*Agropyron tenerum*).	Shepard [a]	5.74	2.77	32.44	8.90	50.15
Smooth brome-grass (*Bromus inermis*).	do. [a]	8.08	2.06	41.27	10.79	37.80
	Knight and Kepner.[b]	6.21	2.71	29.50	9.47	52.11
Buffalo-grass (*Bulbilis dactyloides*)	Shepard [a]	11.19	2.46	28.74	5.60	52.03
	Knight and Kepner.[b]	11.60	2.42	26.81	8.34	50.83
Blue grama (*Bouteloua oligostachya*)	Shepard [a]	8.69	2.18	31.40	9.11	48.62
Timothy (*Phleum pratense*)	do.[a]	7.39	3.58	34.39	8.84	45.80

[a] Shepard, J. H. Bulletin 40, South Dakota Agricultural Experiment Station, 1894.
[b] Knight, H. G., and Kepner, F. E. Bulletin 76, Wyoming Agricultural Experiment Station, 1906.

It will be noted that in the percentage of fats (ether extracts) western wheat-grass is very high, being excelled only by timothy. It is also high in amount of crude protein, but is excelled in this by

Bromus inermis. It is therefore very rich in two of the most important food constituents, and this accounts for its great feeding value as demonstrated by the practical feeder. One other character which may be mentioned is the comparatively concentrated form of the cured hay; that is, the weight per unit volume is great as compared with most hay grasses.

Breeding work was begun with western wheat-grass at the Highmore substation by Prof. W. A. Wheeler in 1905. These breeding plats were visited several times by the writer, the last visit having been made in August, 1908. At this time there appeared to be considerable uniformity in many of the progeny rows from the first selections. South Dakota No. 34–89 was uniformly more spreading than the rows at each side of it; No. 34–105 was also noticeably spreading in habit of growth, while No. 34–81 was close growing, showing a slight approach to bunch-grass habit.

Breeding work was begun at the Bellefourche Experiment Farm in 1908 with bulk seed harvested from natural meadows near the farm. It is desired to secure a drought-resistant and productive strain, suitable for establishing permanent grass meadows on unirrigated land. It is very important to improve the seed production and percentage germination of the seed and the early growth habits of the plant. The germination of the seed is poor and slow and the early growth is not vigorous. It is therefore difficult to obtain a good stand of the grass. Both spring and autumn seeding are being tested to determine which method will produce the better stand. The results so far are not conclusive.

A breeding nursery has been established with single plants in hills 42 inches apart each way. These were grown from seed planted in the field in 1909.

SLENDER WHEAT-GRASS.

Slender wheat-grass, botanically known as *Agropyron tenerum*, appeared to be valuable as a cultivated hay grass in variety tests by the South Dakota substation at Highmore, and by the Office of Forage-Crop Investigations at Bellefourche. The seed germinates freely and the first season's growth is good, so that there is not the difficulty in securing a stand that is experienced with western wheat-grass; but this species is apparently not so drought resistant as brome-grass and western wheat-grass.

Seed collected from plants growing native in western South Dakota was planted in the grass nursery at Bellefourche in 1908 (Pl. IV, fig. 2). In 1909 individual plants were selected from this nursery and these will form the basis of the breeding work with this grass.

Considerable variation among the individual plants was noted in height, amount of stooling, and leafiness. The most desirable types were those which have the leaves extending well up along the culms, thus producing a very leafy plant. There was much variation in this regard. In 1910 the seed of these selections was planted in rows so that a close comparison could be made of their progeny. A few individual plant selections of slender wheat-grass were furnished by the Office of Forage-Crop Investigations, and these were planted in progeny rows in 1909.

AGROPYRON CRISTATUM.

The grass botanically known as *Agropyron cristatum*, recently introduced from Siberia by the United States Department of Agriculture, gives evidence of being a very hardy grass. In cooperation with the Office of Forage-Crop Investigations, seed of six different lots, S. P. I. Nos. 19536 to 19541, inclusive, was planted in the grass nursery at Bellefourche in 1908 (Pl. IV, fig. 1), and larger areas were planted again in 1909. It was observed that this species starts growth very early in the spring, and is not injured by severe frosts. In habit of growth it is like slender wheat-grass, being a "bunch-grass" without creeping rootstocks, but in the character of its rather harsh foliage it somewhat resembles western wheat-grass. Further tests will be made of seed from several sources, and if the species proves to be valuable as a hay grass, selections of superior strains will be made.

CANADA PEAS.

The Office of Forage-Crop Investigations tested a large number of varieties of Canada peas, grass peas (*Lathyrus sativus*), and several varieties of vetches at the Bellefourche Experiment Farm in 1908 and 1909. The yields of most of these have not been satisfactory in the two years during which tests have been made. The low yields have probably been due to the newness of the soil at the farm, as the plats were on land broken only one year previous to cropping. Two or three varieties of Canada peas, however, are very promising, and breeding work has been begun with these.

In dry-land farming the need of an annual leguminous crop for use as green manure in short rotations is apparent, and Canada peas promise to be the most valuable crop for this purpose in the northern Great Plains region. The breeding work will be directed to obtaining a more drought-resistant variety than is now grown in the region, combining also fair seed production with a good forage type of plant.

SUMMARY.

The chief limiting factor in the production of crops in the Great Plains area is lack of sufficient moisture. Two ways of increasing crop production in that region are: First, the use of tillage methods which will conserve the moisture in the soil as far as possible for the use of crops; and second, growing drought-resistant varieties.

The object of the plant-breeding work described in this bulletin is to develop strains of some of the common forage crops that are more drought resistant and productive than strains now grown in the region.

Drought-resistant forage-breeding work is now carried on at two farms conducted by the Department of Agriculture in the Great Plains area, at Bellefourche, S. Dak., and at Akron, Colo. These farms are fairly representative of a large part of the northern and central Great Plains.

In breeding alfalfa for this region, while drought resistance is the principal object in view, such characters as resistance to winter-killing, superior forage yield, and good seed production can not be neglected.

The results of the breeding work with alfalfa indicate that superior forage production and superior seed production are not antagonistic, but may be combined in one plant or strain.

Maximum seed production in alfalfa can be obtained by growing plants in hills, allowing thorough cultivation of the soil. This method can be recommended only where seed is the chief object of the crop.

Breeding sorgo at Bellefourche has been undertaken for the purpose of developing a drought-resistant and early-maturing strain of good forage quality. The existence of such a strain would extend the use of the crop considerably north of its present area.

Most millet varieties now on the market are mixtures of more or less distinct types. In the breeding work conducted by this office, several promising types have been segregated and have shown a high degree of uniformity. They will be tested further for drought resistance, early maturity, and forage yield.

Numerous species of grasses have been tested for drought resistance in the course of the breeding work at Highmore, and by the Office of Forage-Crop Investigations at Bellefourche and other stations in the Great Plains area. Breeding work is in progress with species that have proved drought resistant and otherwise valuable, including smooth brome-grass, western wheat-grass, and slender wheat-grass.

CONCLUSION.

It is intended to test thoroughly the improved strains which have been developed in the course of this work in order to determine their relative drought resistance in comparison with varieties now grown in the region. The most promising strains of alfalfa will also be thoroughly tested in respect to their hardiness. As soon as definite results from these tests of drought resistance and hardiness are obtained, seed of such strains as may prove resistant will be increased and distributed.

PLATES.

DESCRIPTION OF PLATES.

PLATE I. Alfalfa breeding at the Bellefourche Experiment Farm, South Dakota. Fig. 1.—Alfalfa plants in the breeding nursery, showing the first season's growth. The photograph was taken July 29, 1909, three months after planting. The rows are from individual plant selections of the second generation, South Dakota No. 167. Fig. 2.—Selected strains of alfalfa in double-cultivated rows (rows 7 inches apart alternating with cultivated space 32 inches wide).

PLATE II. Sorgo at the Highmore substation and the Bellefourche Experiment Farm, South Dakota. Fig. 1.—Sorgo, South Dakota No. 341, at the Highmore substation, South Dakota. The selected strain at the left is ten days earlier than the bulk seed of the same variety at the right. Fig. 2.—Sorgo progeny row No. 10, showing uniform type of plants. Grown at the Bellefourche Experiment Farm, South Dakota, in 1909, from seed of a single plant selected in 1908.

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FIG. 1.—ALFALFA PLANTS IN THE BREEDING NURSERY, SHOWING THE FIRST SEASON'S GROWTH.

FIG. 2.—SELECTED STRAINS OF ALFALFA IN DOUBLE-CULTIVATED ROWS.

ALFALFA BREEDING AT THE BELLEFOURCHE EXPERIMENT FARM, SOUTH DAKOTA.

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FIG. 2.—SORGO PROGENY ROW AT THE BELLEFOURCHE EXPERIMENT FARM, SOUTH DAKOTA, SHOWING UNIFORMITY OF PLANTS.

SORGO AT THE HIGHMORE SUBSTATION AND THE BELLEFOURCHE EXPERIMENT FARM, SOUTH DAKOTA.

FIG. 1.—SELECTION ROWS.

FIG. 2.—PROGENY ROWS.

KURSK MILLET AT THE BELLEFOURCHE EXPERIMENT FARM, SOUTH DAKOTA.

FIG. 1.—ROWS OF AGROPYRON CRISTATUM.

FIG. 2.—ROWS OF AGROPYRON TENERUM.

AGROPYRON IN THE GRASS NURSERY AT THE BELLEFOURCHE EXPERIMENT FARM, SOUTH DAKOTA.

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PLANT OF A WILD SOY BEAN, NO. 22428, GROWN IN A GREENHOUSE.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 197.

B. T. GALLOWAY, *Chief of Bureau.*

THE SOY BEAN; HISTORY, VARIETIES, AND FIELD STUDIES.

BY

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AND

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Issued December 31, 1910.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1910.

BUREAU OF PLANT INDUSTRY.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., August 3, 1910.

Sir: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 197 of the series of this Bureau the accompanying manuscript entitled "The Soy Bean; History, Varieties, and Field Studies."

This paper was prepared by Mr. C. V. Piper, Agrostologist, and Mr. W. J. Morse, Scientific Assistant, of the Office of Forage-Crop Investigations.

The soy bean is a striking example of a crop with very numerous varieties, the wealth of which has been largely disclosed by the studies here presented. This crop is already of considerable value in the United States, and there can be but little doubt that it is destined to become of much greater importance, not only for forage, but in all probability for the production of oil and oil cake. The results here presented bring together much information that will be of interest to students and experimenters, and which, it is believed, will be of material assistance to all agronomic investigators.

Respectfully,

G. H. Powell,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE SOY BEAN; HISTORY, VARIETIES, AND FIELD STUDIES.

BOTANICAL HISTORY AND IDENTITY OF THE SOY BEAN.

The soy bean was first made known to Europeans by Kämpfer, who spent three years, 1690 to 1692, in Japan. Kämpfer (Amœnitatum Exoticarum, 1712, p. 837) gives the Japanese name "Daidsu Mame" and describes it as an erect bean, with the pod of a lupine and the seeds like a large white pea. Linnæus (Flora Zeylanica, 1747, p. 534) describes the plant briefly under "Dolichos" and states that it is cultivated in Ceylon. This last statement is probably an error. He also cites the descriptions of Kämpfer. In 1753 Linnæus repeats the description of the Flora Zeylanica and formally names the plant *Dolichos soja*, giving its habitat, however, as India. What Linnæus's Ceylon or India plant may be is not certain, as will appear.

Moench in 1794 rechristened the Linnæan plant *Soja hispida*. Savi in 1824 called the Japanese soy bean *Soja japonica*. Miquel in 1855 named a narrow-leafed form from Java *Soja angustifolia*, and Maximowicz in 1873, using Moench's specific name, published the soy bean as *Glycine hispida*, which name has been generally adopted. Siebold and Zuccarini had previously (1843) named a plant from Japan *Glycine soja*, supposing it to be the *Dolichos soja* of Linnæus. This plant, however, was not the soy bean cultivated by the Japanese but the wild plant later described as *Glycine ussuriensis* by Regel and Maack. Under existing botanical rules, the soy bean, which is known only as cultivated, has been called *Glycine hispida* (Moench) Maximowicz, and its nearest relative *Glycine soja* Siebold and Zuccarini (*G. ussuriensis* Regel and Maack). Maximowicz considered that the soy bean was probably derived from the latter by cultivation, but this idea has not generally been accepted.

Glycine soja (Pls. I and II), as heretofore known, differs from *G. hispida* in its more slender and more vining stems, in being less hairy, in bearing smaller pods and seeds, and especially in having smaller flowers. The flower is 3 to 5 mm. long, while that of *G. hispida* is 6 to 7 mm. The structure of the flower is the same in both, but the calyx lobes are usually longer in proportion to the tube in *G. hispida* than in *G. soja*. It is apparent, therefore, that the fundamental differences between the species are slight. The smaller flower we

regard as the best single character to separate *G. soja* from *G. hispida*, but using this as a criterion *G. soja* is also a cultivated species.

Among numerous lots of seeds received from India (S. P. I. Nos. 24672 to 24693, inclusive) representing seven varieties, there are at least two (see Nos. 24675 and 24682) which have very small flowers, 3 mm. long, indistinguishable from those of the wild *G. soja* that we have grown. Typical plants of *Glycine soja* obtained from the Botanic Garden, Tokyo, Japan (S. P. I. No. 22428), and from Soochow, Kiangsu, China (S. P. I. No. 25138), have been grown three seasons. The India plants are coarser stemmed, less vining, and bear somewhat larger pods and seeds, but the flowers are much smaller than those of any variety of *G. hispida* and precisely like those of *G. soja*. Other numbers from India are probably *G. hispida*, but the flowers are somewhat smaller than the Japanese varieties and the pods and seeds as small as any variety of *G. hispida*. It is therefore apparent that both *G. soja* and *G. hispida* are cultivated in parts of India, if we accept the flower character as decisive. This fact makes it doubtful which of the two plants Linnæus named *Dolichos soja*. There seems no good reason why *G. hispida* may not have been derived from *G. soja* by cultivation, the smaller flowers of the latter being the principal difficulty to explain. In all other respects the two supposed species seem to merge completely. The identity of the plant cultivated in India has been commented on by Watt (Dictionary of the Economic Products of India, 1890, p. 509) as follows:

Reference having been made to the authorities of the Calcutta Herbarium on the subject of *G. soja*, Sieb. et Zucc., being, as shown in the Flora of British India, a native of this country, Dr. Prain kindly went into the subject very carefully. He writes: "We have not, from any part of India, any specimens of *G. soja* proper. The Khasi Hills plant is more erect, more hispid, and has larger legumes than the Himalayan, and indeed resembles *G. hispida*, Maxim., quite as much as it does the Indian cultivated '*G. soja*,' which, indeed, it connects with *G. hispida*. It is, in fact, the plant most like the wild *G. soja*, S. et Z., which no one ever professes to have found wild in India, while it is also the one most like *G. hispida*, Maxim. (which has never been found wild anywhere). It is the plant collected by Dr. Watt and myself in the Naga Hills."

The writer noted on his Naga Hill specimens that they were found in a semiwild state, and that the plant was known to the Angami Nagas as *Tsu Dza*, a name not unlike *soja*. Throughout India, the soy bean is cultivated, black and white seeded forms being met with, which vary to some extent, but all preserve the specific characters of *G. hispida*. Plants raised at Saharunpur from Japanese seed have larger and broader leaves than the usual Indian forms. The fact that this cultivated plant possesses, even among the aboriginal tribes, names which are original, i. e., in no way modern derivatives, points to an ancient cultivation, if, indeed, it may not be accepted as an indication of its indigenous nature. (Editor.)

Prain apparently does not apply the size of the flower as a critical character. Applying this, however, two of the Indian varieties (see

Nos. 24675 and 24682) are certainly *Glycine soja*, but the plants are stouter and less twining, and the pods and seeds larger than the wild form from Japan. Three other varieties (Nos. 24672, Khasi Hills, and 24673 and 24674, Darjiling) we would refer to *G. hispida*, though the flowers are somewhat smaller than the Japanese and Chinese varieties. The first is erect and bushy, but the other two are procumbent and vining. A variety from Taihoku, Formosa, No. 24642, is very similar to the two varieties from Darjiling. On the whole, we are therefore inclined to believe that there is but one botanical species, which has been profoundly modified by cultivation.

BOTANICAL CLASSIFICATIONS OF SOY-BEAN VARIETIES.

The numerous varieties of soy beans have led some botanists to give them botanical designations, but these for the most part have been ignored by later writers.

Roxburgh (catalogue, p. 55) described a variety in the Calcutta Botanical Garden as *Soja hispida pallida*, stating that it had yellow flowers and white seeds. Voigt (Hortus Suburbanus Calcuttensis, p. 231) apparently redescribes the same plant as *Soja hispida leucosperma*. There is perhaps an error here as all of the varieties of soy beans grown by us have either white or purple flowers and none have truly white seeds.

Martens (Die Gartenbohnen, 1869) discusses the soy bean under the name *Soja hispida* Moench and gives a classification of thirteen varieties that he had secured from various sources, of which he apparently grew but one. He divides the species into three subspecies based on the form of the seed, under which the varieties are named according to the color of the seed.

I. *Soja elliptica* Martens. Seeds oval.
   1. *S. elliptica nigra*. Seeds black; obtained from Shanghai and Paris.
   2. *S. elliptica castanea*. Seeds brown; obtained from Chefoo, Venice, and Berlin.
   3. *S. elliptica virescens*. Seeds greenish yellow; obtained from Paris.
   4. *S. elliptica lutescens*. Seeds yellow; obtained from Chefoo.

II. *Soja sphaerica*. Seeds globose.
   5. *S. sphaerica nigra*. Seeds black, large; obtained from Japan.
   6. *S. sphaerica minor*. Seeds black, small; obtained from Japan and Sumatra.
   7. *S. sphaerica virescens*. Seeds greenish: obtained from Shanghai and Yokohama.
   8. *S. sphaerica lutescens*. Seeds yellow, large; obtained as "New Japan peas" from Norway. This is identified as var. *pallida* of Roxburgh.
   9. *S. sphaerica minima*. Seeds yellow, small; obtained from Yokohama.

III. *Soja compressa*. Seeds compressed.
   10. *S. compressa nigra*. Seeds black, very large; obtained from Yokohama.
   11. *S. compressa parvula*. Seeds black, small; obtained from Chefoo.
   12. *S. compressa virescens*. Seeds greenish; obtained from Berlin as *Soja ochroleuca* Bouché.
   13. *S. compressa zebrina*. Seeds brown banded with black; obtained from the Berlin Botanic Garden.

Harz (Zeitschrift des Landw. Vereins Bayern, 1880, and Landwirtschafthliche Samenkunde Handbuch, 1885) gives an even more elaborate classification than Martens of the varieties of *Soja hispida*, dividing the species into two subspecies on the form of the pod, and numerous varieties on the shape and color of the seeds, but it is not apparent that he grew the plants. His grouping is as follows:

Soja platycarpa Harz. Flat-podded soy beans.

1. *olivacea* Harz. Seeds olive-brown.
2. *punctata* Harz. Seeds olive, speckled with brown.
3. *melanosperma* Harz. Seeds black, elongate (*Soja compressa nigra* Martens).
   a. *vulgaris*. Hilum flat; seeds 9.1×5.5×3.5 mm.
   b. *renisperma*. Hilum concave; seeds 10.1×5×3.8–4 mm.
   c. *nigra*. (*Soja elliptica nigra* Martens.) Seeds little compressed, 11×5.1×4.4 mm.
   d. *rubrocincta*. Like the preceding, but dark red about the hilum.
4. *platysperma* Harz. Seeds black, flat.
5. *parvula* Martens. Seeds black, small.

Soja tumida Harz. Swollen-podded soy beans.

6. *pallida* Roxb. Seeds yellow or yellowish.
7. *castanea* (*Soja elliptica castanea* Martens). Seeds brown.
8. *atrosperma* Harz. (*Soja sphaerica nigra* and *S. sphaerica minor* Martens.) Seeds black.

This classification differs from that of Martens primarily in recognizing two main groups based on the shape of the pod rather than three groups based on the form of the seed.

While either the system of Martens or that of Harz will classify the material, they are of little value either botanically or agronomically. To accommodate the much larger number of varieties we have studied, either scheme would need to be elaborated greatly. Furthermore, there are all possible intergrades between flat pods and tumid pods, as also between oval, globose, and compressed seeds. Botanically speaking, the form of the pod and the color and form of the seeds is of little significance. Agronomically the habit and size of the plants are much more important characters, and in many cases varieties very different in these respects have closely similar seeds.

VARIETAL CHARACTERISTICS OF SOY BEANS.

The characters that distinguish soy-bean varieties may be considered under the following categories:

HABIT OF GROWTH.

All soy beans are strictly determinate as to growth; that is, the plants reach a definite size according to environment and then mature and die. The great majority of the varieties are erect and branching, with a well-defined main stem. (Pls. II and III.) The branches may all be short, or the lower ones elongated, either spreading or ascending.

In other varieties the stems and branches, especially the elongated terminals, are more or less twining and usually weak, so that the plant is only suberect or even procumbent. (Pls. I, II, and III.) In the bushy forms the internodes may be short, in which case the pods are more or less densely crowded or elongated, causing the pods to be scattered. Varieties with elongated internodes are usually slender and the pods small, but this is by no means universal. The form of the plant may be greatly modified by thickness of planting, as the development of the branches is inhibited by close planting and encouraged by isolation.

FOLIAGE.

There is wide variation in the leaves of soy beans, involving shape, size, color, and degree of persistence. These characters merge by insensible degrees, so that they are useful in differentiating varieties only in extreme cases. In shape, the leaflets are usually ovate-lanceolate, but in some varieties are narrowly lanceolate or almost linear; in others, nearly orbicular. They vary in length from 1 inch to 5 inches. In color they are usually pale, but some are dark green.

In nearly all varieties of soy beans the leaves commence to turn yellow as the pods begin to ripen and commonly all have fallen when the pods are mature. On this account it is difficult to harvest the crop for grain and save all the foilage as well, but this is possible with many varieties. A few sorts, like the Wisconsin Black, retain their leaves green until all or nearly all of the pods are mature.

Additional leaflets occur not uncommonly in several varieties. This seems to be especially true with early sorts from Siberia, on which leaves with four or five leaflets are frequently seen.

PUBESCENCE.

All soy beans are hairy plants, and there is but little difference in the amount of hairiness. No smooth variety has thus far been obtained, the nearest approach to it being No. 22876, from Tokyo, Japan. The pubescence occurs in two colors, white or gray and tawny, which behave in Mendelian fashion, the tawny being dominant. The tawny pubescence is nearly always on tawny-colored or dark pods and the white pubescence on grayish pods. Many cases occur where two varieties differ wholly or mainly in the color of the pubescence. In some instances these have been segregated; in others the mixture is evident. In such cases one color usually predominates, the presence of the other being due to casual hybridization.

FLOWERS.

Soy-bean flowers occur in two colors, purple and white. Certain varieties can be distinguished most readily by this character. In a number of the lots tested both colors of flowers occur, the plants

Chernie, Jet, and Meyer extremely sensitive. The comparative resistance of the varieties is reported as follows, the first being least injured: (1) Ogemaw; (2) Haberlandt, Ito San, Kingston, Guelph; (3) Habaro, Shingto, Manhattan, Brindle; (4) Jet; (5) Meyer, Chernie.

It may be that the same variety varies in frost resistance, depending on its stage of maturity. In the foregoing list, however, the Ogemaw, though very early, usually matures with the Manhattan and the Chernie, while the Haberlandt is fifteen days later.

PERIOD OF MATURITY.

In soy beans there is a continuous succession of varieties from very early to very late. With very few exceptions, earliness is correlated with size, the largest varieties being latest. As in the cowpea, early plantings take a longer time to mature than late plantings, but there is by no means a consistent behavior in the different varieties in this respect. In general, the later the variety the more is its life period shortened by later planting.

Haberlandt, in 1877, planted one variety at Vienna at intervals of one week through the season and attempted to correlate the life periods obtained with the amount of heat. His results are shown in Table I.

TABLE I.—*Results of planting a single variety of soy bean at different dates, Vienna, Austria, 1877.*

Date of planting.	Date of harvest.	Life period.	Total heat required— Until germination.	Until blossoming.	Until maturity
		Days.	° *C.*	° *C.*	° *C.*
March 31	September 29	182	230	1,185	2,972
April 7	....do	175	294	1,102	2,898
April 14	....do	167	189	1,008	2,787
April 21	....do	160	217	1,026	2,753
April 28	....do	153	228	995	2,701
May 5	October 15	163	209	936	2,811
May 12	....do	156	221	960	2,722
May 19	October 18	152	275	1,043	2,641
May 26	....do	145	153	985	2,519
June 2	....do	138	152	871	2,405
June 9	October 26	139	130	739	2,322

Prof. C. A. Mooers, of the Tennessee Agricultural Experiment Station, has conducted extensive experiments of a similar kind. The following table gives some of his results:[a]

TABLE II.—*Life period of soy-bean varieties planted at intervals of two weeks for two consecutive years at the Tennessee Agricultural Experiment Station.*

Variety.	1907. Date planted.	1907. Date harvested.	1907. Life period.	1908. Date planted.	1908. Date harvested.	1908. Life period.
			Days.			Days.
Mammoth	April 3	October 5	186	April 2	October 7	188
	April 15	do	173	April 14	do	179
	April 30	October 6	160	May 1	do	159
	May 15	October 9	146	May 15	do	145
	June 5	October 12	129	June 1	do	128
	June 17	October 22	127	June 17	October 21	126
	June 29	do	113	July 1	do	112
	July 15	October 28	105	July 16	October 24	100
Medium Yellow	April 3	September 13	164	April 2	August 15	135
	April 15	do	151	April 14	September 7	146
	April 30	do	137	May 1	September 14	136
	May 15	September 18	135	May 15	do	122
	June 5	September 20	107	June 1	September 19	110
	June 17	September 27	102	June 17	September 23	98
	June 29	do	90	July 1	September 28	89
	July 15	October 9	86	July 16	October 17	93
	August 6	October 29	84	August 1	October 24	85
Ito San	April 3	August 9	129	April 2	July 25	114
	April 15	do	117	April 14	July 29	106
	April 30	do	102	May 1	August 5	96
	May 15	August 17	93	May 15	August 15	92
	June 5	September 3	90	June 1	August 27	87
	June 17	September 18	93	June 17	September 10	85
	June 29	do	81	July 1	September 19	80
	July 15	October 9	85	July 16	October 6	82
	August 6	October 29	84	August 1	October 24	85

A large list of varieties has been grown for several years past at the Arlington Experimental Farm, planted each year during the first week in June. In period of maturity nearly all the varieties behave consistently from season to season, as indicated in Table III, on the following page.

[a] Bulletin 82, Tennessee Agricultural Experiment Station, December, 1908.

TABLE III.—*Life periods of soy beans grown at the Arlington Experimental Farm, near Washington, D. C., for three or four seasons.*

Variety.	1905.			1907.		
	Date planted.	Date harvested.	Life period.	Date planted.	Date harvested.	Life period.
			Days.			*Days.*
No. 14952, Shanghai				June 5	October 20	137
No. 14953, Edward				..do	October 15	132
No. 14954, Acme				..do	..do	132
No. 16789, Brooks				..do	October 7	124
No. 16790, Cloud				..do	..do	124
No. 17251, Buckshot	June 3	September 14	103	..do	September 16	103
No. 17252, Flat King	..do	October 19	128	..do	October 15	132
No. 17253, Nuttall	..do	September 25	114	..do	September 30	117
No. 17254, Ebony	..do	October 3	122	..do	October 6	123
No. 17255, Kingston	..do	September 25	114	..do	September 30	117
No. 17256, Brownie	..do	October 2	121	..do	October 7	124
No. 17257, Eda	..do	September 23	112	..do	September 30	117
No. 17258, Ogemaw	..do	August 30	88	..do	September 15	102
No. 17260, Samarow	..do	September 14	103	..do	..do	102
No. 17261, Guelph	..do	September 23	112	..do	September 30	117
No. 17262, Yosho	..do	September 14	103	..do	September 20	107
No. 17263, Austin	..do	September 30	119	..do	October 10	127
No. 17264, Tokyo	..do	October 30	149	..do	October 20	137
No. 17267, Hope	..do	..do	149	..do	October 21	138
No. 17268, Ito San	..do	September 24	113	..do	September 30	117
No. 17269, Medium Yellow	..do	October 2	121	..do	October 7	124
No. 17271, Haberlandt	..do	September 30	119			
No. 17273, Butterball	..do	September 7	96	June 5	September 30	117
No. 17275, Amherst	..do	September 25	114	..do	October 5	122
No. 17277, Manhattan	..do	September 7	96	..do	September 30	117
No. 17278, Hollybrook	..do	October 14	133	..do	October 20	137
No. 17280, Mammoth	..do	October 28	147	..do	October 25	142
No. 17861, Jet				..do	September 30	117
No. 18227, Chernie				..do	..do	117

Variety.	1908.			1909.		
	Date planted.	Date harvested.	Life period.	Date planted.	Date harvested.	Life period.
			Days.			*Days.*
No. 14952, Shanghai	June 6	October 25	141	June 2	October 30	150
No. 14953, Edward	..do	October 28	144	..do	November 5	156
No. 14954, Acme	..do	October 20	136	..do	October 25	145
No. 16789, Brooks	..do	October 8	124	..do	October 9	129
No. 16790, Cloud	June 9	October 7	120	..do	..do	129
No. 17251, Buckshot	..do	September 16	99	June 7	September 15	100
No. 17252, Flat King	..do	October 15	128	June 2	October 16	136
No. 17253, Nuttall	..do	October 8	121	June 7	October 4	119
No. 17254, Ebony	..do	..do	121	June 2	..do	124
No. 17255, Kingston	..do	October 5	118	..do	..do	124
No. 17256, Brownie	..do	October 8	121	..do	..do	124
No. 17257, Eda	..do	October 1	114	June 7	September 27	112
No. 17258, Ogemaw	..do	September 22	105	..do	..do	112
No. 17260, Samarow	..do	..do	105	..do	..do	112
No. 17261, Guelph	..do	October 5	118	June 2	..do	117
No. 17262, Yosho	June 8	September 21	104	June 7	September 24	109
No. 17263, Austin	..do	October 9	123	June 2	October 16	136
No. 17264, Tokyo	June 6	October 20	134	..do	October 30	150
No. 17267, Hope	..do	..do	134	..do	October 29	149
No. 17268, Ito San	June 8	September 22	106	June 7	October 2	117
No. 17269, Medium Yellow	..do	October 9	123	June 2	October 4	124
No. 17271, Haberlandt	..do	October 5	119	..do	October 9	129
No. 17273, Butterball	..do	September 21	105	June 7	September 27	112
No. 17275, Amherst	..do	October 5	119	June 2	October 4	124
No. 17277, Manhattan	..do	September 14	98	June 7	September 20	105
No. 17278, Hollybrook	June 6	October 12	128	June 2	October 18	138
No. 17280, Mammoth	..do	October 30	146	..do	October 30	150
No. 17861, Jet	June 8	October 10	124	..do	October 9	129
No. 18227, Chernie	June 9	September 30	112	June 7	September 20	105

Based on the data from the Arlington Experimental Farm, the varieties may be classified into seven groups according to their life periods:

Very early	Maturing in 80 to 90 days.
Early	Maturing in 90 to 100 days.
Medium early	Maturing in 100 to 110 days.
Medium	Maturing in 110 to 120 days.
Medium late	Maturing in 120 to 130 days.
Late	Maturing in 130 to 150 days.
Very late	More than 150 days.

CHANGES IN LIFE PERIOD.

Ball, in Bulletin 98 of the Bureau of Plant Industry, page 8, cites the case of Agrostology No. 1299 (S. P. I. No. 17276), obtained from France in 1902, as illustrating that a variety may progressively change from early to late. According to Ball's records, this variety matured at the Arlington Experimental Farm in 1902 in 95 days; in 1903, in 120 days; in 1905, in 130 days. On the other hand, at Knoxville, Tenn., the record of this variety is perfectly consistent from year to year and it matures with the Buckshot, a very early variety.[a] Planted August 2, 1906, both matured in 70 days; planted May 25, 1907, both matured in 91 days; planted July 11, 1907, both matured in 81 days; planted July 30, 1907, both matured in 84 days; planted May 13, 1908, both matured in 80 days; planted July 17, 1908, both matured in 82 days.

No. 1299 was not grown at the Arlington Experimental Farm after 1905 until 1909, when seed was obtained from the Tennessee Agricultural Experiment Station. In this year it matured in 100 days, exactly the same as required for Buckshot that had been grown continuously at Arlington.

It seems difficult to reconcile these results with those reported by Ball, but the subject needs further investigation.

In the case of the Ogemaw variety, phenomena have occurred that are precisely like those reported by Ball. As shown by Table III, this variety required the following periods to mature at the Arlington Experimental Farm: In 1905, 88 days; in 1907, 102 days; in 1908, 105 days; in 1909, 112 days. In all these years the variety remained perfectly uniform and no variants have ever been found in it. In 1909 seed of this variety was secured from several sources to see if any changes in its life period, which was suspected from its increasing lateness at Arlington, had actually occurred. The results are shown in Table IV. All of these lots of the Ogemaw variety came from the same original source, namely, Mr. E. E. Evans, West Branch, Mich.

[a] Bulletin 82, Tennessee Agricultural Experiment Station, p. 81, 1908.

The limited amount of data concerning three other varieties indicate that Butterball has likewise become later at Arlington or earlier at the Minnesota Agricultural Experiment Station, while no change has taken place in Buckshot and Manhattan.

TABLE IV.—*Variation in life periods of four soy-bean varieties, apparently due to place effect.*

Variety.	Serial No.	Period of maturity at the Arlington Experimental Farm, 1909.	Source of seed.
		Days.	
Ogemaw......	0855	84	Minnesota Agricultural Experiment Station, 1908, where grown 5 years from S. P. I. No. 13502 from Agrostology No. 1992.
Do.......	0854	87	Minnesota Agricultural Experiment Station, 1908, where grown 4 years from Agrostology No. 1992.
Do.......	0856	87	Minnesota Agricultural Experiment Station, 1908, original seed from Kansas in 1900.
Do.......	0857	87	Minnesota Agricultural Experiment Station, 1908, original seed from Michigan in 1903.
Do.......	0858	87	Do.
Do.......	21755	87	Arlington Experimental Farm, 1908, from seed from Paris, France.
Do.......	25212	87	Bremen, Germany.
Do.......	0866	92	Idaho Agricultural Experiment Station, 1908, grown there several years.
Do.......	0865	97	Idaho Agricultural Experiment Station, 1908, original seed from Minnesota Agricultural Experiment Station, 1907.
Do.......	17258	112	Arlington Experimental Farm, 1908, where grown for 6 years.
Buckshot.....	17251	100	Do.
Do.......	0859	101	Minnesota Agricultural Experiment Station, 1908, grown several years from Agrostology No. 1303.
Do.......	0860	101	Minnesota Agricultural Experiment Station, 1908, grown several years from Agrostology No. 1979.
Do.......	0861	101	Minnesota Agricultural Experiment Station, 1908, grown several years from Agrostology No. 1978.
Manhattan...	17277	105	Arlington Experimental Farm, 1908, where grown for 6 years from Agrostology No. 1295.
Do.......	0862	105	Minnesota Agricultural Experiment Station, 1908, where grown for several years from Agrostology No. 1295.
Do.......	8422	117	Arlington Experimental Farm, 1908, from seed grown several years at Illinois Agricultural Experiment Station from Agrostology No. 1199.
Butterball....	0863	105	Minnesota Agricultural Experiment Station, 1908, where grown for several years from Agrostology No. 1197.
Do.......	0864	105	Minnesota Agricultural Experiment Station, 1908, where grown for several years from Agrostology No. 1199.
Do.......	17273	112	Arlington Experimental Farm, 1908, where grown for 6 years from Agrostology No. 1197.

POLLINATION AND HYBRIDIZATION.

The soy-bean flower is completely self-fertile, bagged plants setting pods as perfectly as those in the open. This was tested at the Arlington Experimental Farm in 1909 by bagging 30 plants representing 10 varieties. In no case did the bagged individuals fail to produce as well as neighboring unbagged plants. Ten plants were also inclosed in box screens with similar results.

The flowers are much visited by bees, mainly for the pollen, as but a very small quantity of nectar is secreted. Cross-pollination would be of frequent occurrence were it not that the abundant pollen of each flower covers the stigma almost as soon as the flower opens.

Previous to 1907 the remarkable uniformity of the plats at the Arlington Experimental Farm, except for occasional and evident admixtures, had led to the belief that natural hybrids of the soy bean did not occur. In that year the occurrence of certain oddly colored seeds, smoky green, smoky yellow, brown and yellow, etc., in the bulk seed was noted. These were carefully saved and the resultant rows in 1908 gave diverse progeny, showing that some of the seeds at least were hybrids. In 1908 more than a hundred single-plant selections of supposed hybrids were made and planted in 1909. Some of the results are indicated in Table V.

TABLE V.—*Variations in hybrid soy-bean plants and their progeny at the Arlington Experimental Farm, 1908–1910.*

Serial No.	Hybrid.		Progeny.			
	Color of pubescence.	Color of seed.	Total number of plants.	Color of pubescence.	Color of flower.	Color of seed.
1826	Tawny	Cloudy green	50	Tawny	Purple	Green, 39; black, 10; cloudy green, 1.
1830	do	Olive-yellow	44	Tawny, 32; gray, 12	White	Olive-yellow.
1840	do	do	42	Tawny	Purple	Olive-yellow with black hilum, 2; olive-yellow with seal-brown hilum, 40.
1856	do	do	22	Tawny, 18; gray, 4	Some purple, some white	Varying from straw-yellow to olive-yellow.
1878	do	Black with brown specks	32	Tawny, 27; gray, 5	Purple	Black with brown specks, 20; black, 8; brown, 4.
1896	Gray	Olive-yellow	40	Gray, 38; tawny, 2	Some purple, some white	Olive-yellow.
1901	do	Straw-yellow	33	Gray, 32; tawny, 1	White	Straw-yellow.
17253 C-1	do	Olive-yellow	8	Tawny, 7; gray, 1	do	Olive-yellow, 3; brown, 5.
17253 C-3	Tawny	Black	8	Tawny	Purple	Black, 7; black and brown, 1.
17253 C-4	do	Brown	13	Tawny, 10; gray, 3	do	Dark brown, 9; light brown, 3; black, 1.
17253 C-5	do	Olive to brown	18	Tawny	Some purple, some white	Green, 1; olive to brown, 17.
17253 C-6	do	Straw-yellow	38	do	do	Straw-yellow, 28; brown, 10.
17253 C-7	do	Olive to brown	40	do	do	Black, 2; olive to brown, 38.
17253 C-8	do	do	30	Tawny, 25; gray, 5	do	Light brown, 5; olive-green, 25.
17255 A	do	Green	28	Tawny	do	Green, 22; black, 5; cloudy green, 1.
17257 A-1	do	Brown	103	do	do	Brown, 101; green, 1; greenish brown, 1.
17257 A-2	do	Black	68	Tawny, 56; gray, 12	do	Black, 54; brown, 12; olive, 2.
17257 A-9	do	Olive-yellow	26	Tawny, 19; gray, 7	White	Olive-yellow, 23; black, 3.
17257 A-10	do	Brown	21	Tawny, 17; gray, 4	do	Reddish-brown, 17; light brown, 4.
17262-1	do	Olive-yellow	50	Tawny, 37; gray, 13	do	Olive-yellow, dark hilum, 37; pale hilum, 13.
17263 B-1	do	do	96	Tawny, 75; gray, 21	do	Olive-yellow.
17277 C	do	Brown	58	Tawny, 42; gray, 16	Purple	Dark brown, 42; light brown, 16.
17852 L-1	do	Straw-yellow	72	Tawny	Purple, 56; white, 16	Straw-yellow, 54; brown and black, 14; brown, 4.
17852 L-2	do	Olive-yellow	85	do	Purple	Olive-yellow, 74; brown and black, 10; black, 1.
17852 L-3	do	Black and brown	81	do	do	Black and brown, 54; brown, 26; black, 1.
17852 L-4	Gray	Brown	85	Gray, 84; tawny, 1	Some purple, some white	Yellow, 2; light to dark brown, 83.
17852 L-7	Tawny	Black and brown	77	Tawny	do	Black and brown, 40; brown, 36; yellow, 1.
22379-2	do	Straw-yellow	78	Tawny, 52; gray, 26	Purple	Straw-yellow, brown and yellow.
22411 A-2	do	Black and olive	26	Tawny	do	Black, 19; brown to olive, 7.
25161-1	do	Straw-yellow	55	do	do	Brown, 42; straw-yellow, 13.

It is evident from the diversity of the progeny that the parents were hybrids in all the cases listed. The number of plants grown in each case is too small to secure definite proportions, but it is clear that the color of the pubescence and the color of the seed behave in Mendelian fashion. The same is probably true of the flower color, which was counted in only one case.

There is thus furnished a clear explanation of the origin of many of the new varieties at the Arlington Experimental Farm that were at first mistaken for accidental admixtures. It also accounts for the diversity of the population exhibited in many introduced varieties notwithstanding the apparent uniformity of the seed.

It must not be supposed from the foregoing account that hybrids are common in soy beans. At Arlington the test rows are grown contiguously, so that there is great opportunity for cross-pollination. Nevertheless, the percentage of hybrids that occur is very small, perhaps not one individual in two hundred.

Thus far the hybrid plants have been detected mostly by the color of the seed. In a number of cases none of the progeny has seed similar to the parent; or, in other words, the color of heterozygote seeds is often unstable. Among the most striking of such heterozygote seeds (Pl. VIII) are yellow with a single narrow transverse band of brown; yellow or green, with an irregularly star-shaped brown or black figure centering at the hilum; and green or yellow more or less suffused with a smoky color. Some of the last breed true, but most of them do not.

Heterozygote plants, especially where the seeds are largely or wholly yellow, are often distinguishable by the unusual form of the pods near the tips of the branches. These are more tumid than the other pods and the seeds more crowded. Such pods may also be thinner in texture and much less hairy. Illustrations of this phenomenon are shown in Plate VII.

MUTATIONS.

The origin of new varieties of soy beans without hybridization has apparently occurred in certain cases that have come under our observation. From a theoretical standpoint there can be no doubt that the fundamental diversity in a plant, especially when normally self-pollinated, is brought about by other causes than hybridization. It is self-evident that there must be two different varieties to cross before crossing can become effective in producing new varieties. Most soy-bean varieties when pure remain very constant to type, so that any chance variation is quickly detected. There are two cases in which the evidence is fairly satisfactory that a brown-seeded variety arose as a mutation from a yellow-seeded sort.

Trenton (S. P. I. No. 24610).—This is a brown-seeded variety found by Mr. S. J. Leavell, of Trenton, Ky., in a field of the yellow-seeded Mammoth. Grown side by side at the Arlington Experimental Farm in 1909, the two varieties were indistinguishable by any other character than the seed color.

Riceland (S. P. I. No. 20797).—At the Arlington Experimental Farm this variety has been grown for three seasons, and while it matures but few seeds it is very uniform. At Biloxi, Miss., in 1908, it displayed astonishing diversity. Some plants had very narrow leaves, others very broad, and all degrees of intermediates occurred; some plants were erect, others procumbent; some fruited heavily, others scarcely at all. The seed was saved from individual plants showing the most striking variations, and the resultant plants of each in 1909 were uniform. It is possible that the seed planted at Biloxi contained these forms, but the fact that the same bulk seed gave uniform plants elsewhere indicates that the diversity was a response to the environment. No similar phenomenon has as yet been witnessed in other varieties.

NOMENCLATURE AND CLASSIFICATION.

Most of the varieties of soy beans that were early introduced into the United States received such names as Early Black, Medium Green, Late Yellow, etc., one adjective referring to the period of maturity, the other to the color of the seed. As long as the varieties were few such a system of naming was satisfactory.

In 1907, when the number of varieties had increased to 23, Ball[a] recognized the impracticability of such a system of nomenclature and gave single-term appellations to most of the varieties. On this account, several of the older sorts are now known by two or more names.

At the present time there are known about 300 varieties, mostly obtained in the last three years from Asia by the activities of the Office of Seed and Plant Introduction of the Bureau of Plant Industry. In the synopsis of the varieties here presented they are classified (1) by the type of plant into five groups and (2) by the color of the seeds. A brief description is given of each, but only the more important have been given names. It will be noticed that a considerable number of the varieties are not pure, containing two or more closely similar sorts distinguished by the color of the flowers or the color of the pubescence, or both. Thus, the Acme variety is really a mixture of four sorts, namely, white flowered with gray pubescence, white flowered with tawny pubescence, purple flowered with gray pubescence, and purple flowered with tawny pubescence. These all mature together and the

[a] Bulletin 98, Bureau of Plant Industry, 1907.

seeds are either identical or distinguishable with great difficulty. Nevertheless, the results secured with other varieties leave no question that all these can be separated and bred true to type.

In regard to the brief descriptions given, a few words of explanation are necessary. Many of the importations proved to be impure lots of seeds. In some cases, especially where the seeds were differently colored, these were separated before planting, and such are definitely indicated. In other cases the mixture was not detected until the plants were grown, or, in a few cases, until the seed was harvested. Where the difference was detected in the field and the plants separated, they are referred to as "field selections." On the other hand, if the selection was merely a separation of seed from the garnered crop, these are spoken of as "seed selections." Both the "seed" selections and the "field" selections are for the most part "mass" selections, and many of them prove still to be impure, containing both tawny and gray-haired, or red-flowered and white-flowered varieties, which, however, mature together. Most of these have not been separated, though in all valuable varieties they should be. Where one or the other of such differences is not recorded, the variety is a pure strain. Where the selections were made the first year that the plants were grown from imported seeds, they may be either accidental admixtures or the result of hybridization at the place where the original seed was grown. If, on the other hand, they were selected two or more years after they were introduced, they are almost certainly the result of hybridization at the Arlington Experimental Farm.

Besides these, many individual or centgener selections have been made; these, however, are not considered in the accompanying descriptions. Except these last, all selections are indicated by the original S. P. I. serial number with a letter added, thus 16790 D.

It will be apparent from the descriptions that many varieties are very similar to one another. Only a comparatively few of them have been named. Very careful field comparisons were made, however, in all cases, so that each description represents a different thing.

In the cases of a number of early S. P. I. introductions, new numbers were assigned to different lots of seed grown from the original. Thus, the original introduction of Ebony was S. P. I. No. 6386 and different lots of its progeny were Nos. 8492, 9414, and 17254. This is indicated in each case. Many of these earlier S. P. I. numbers were also distributed under a series of Agrostology numbers, full keys to their respective identities being given by Ball in Bulletin 98 of the Bureau of Plant Industry, so that their identity with the numbers and descriptions here given can be easily determined.

EARLY AGRICULTURAL HISTORY IN THE UNITED STATES.

The first mention of the soy bean in American literature is by Thomas Nuttall, in the New England Farmer, October 23, 1829. Nuttall grew a variety with red flowers and chocolate-brown seeds in the botanic garden at Cambridge, Mass., and from his observations wrote a brief account concerning it. He writes:

> Its principal recommendation at present is only as a luxury, affording the well-known sauce, soy, which at this time is only prepared in China and Japan.

In the same journal two years later, November 23, 1831, is an account of the successful culture of the plant at Milton, Mass., the seed having been obtained from Nuttall.

No further mention of the plant in American literature appears until 1853, when a brief account appeared under the name "Japan pea," by A. H. Ernst, Cincinnati, Ohio, as follows: [a]

> The Japan pea, in which so much interest has been manifested in this country for a year or two past, from its hardihood to resist drought and frost, together with its enormous yield, appears to be highly worthy of the attention of agriculturists.
>
> This plant is stated to be of Japan origin, having been brought to San Francisco about three years since, and thence into Illinois and Ohio. Its habit of growth is bushy, upright, woody, and stiff, branching near the ground, and attaining a height of three or four feet. The leaflets are large, resembling those of an ordinary bean, occurring in sets of three, with long quadrangular stems. The flowers, which are small and white, but rather inconspicuous, sometimes having purple centers.

In the following year, 1854, the Perry expedition brought back two varieties of "soja bean" from Japan, one "white" seeded, the other "red" seeded.[b] These, together with the Japan pea, were distributed by the Commissioner of Patents in 1854, and, thereafter, frequent references to the plant occur in agricultural literature under such names as Japan pea, Japan bean, and Japanese fodder plant.[c] Most of these articles speak of the plant as the Japan pea, none of them as the soy or soja bean. It is apparent from the early accounts that there were at least two Japan peas, one early enough to mature in Connecticut (Patent Office Report, 1854, p. 194), the other very late (American Agriculturist, 1857, vol. 16, p. 10). Judging from all the accounts, we suspect that the early Japan pea may be the Ito San variety, which, however, has red flowers, while the late variety may be the Mammoth. The Ito San is still occasionally called the Japan pea, while the introduction and source of the Mammoth has never been definitely determined. From these early

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[a] Report of the Commissioner of Patents, Agriculture, p. 224.

[b] Report of the Commissioner of Patents, Agriculture, 1854, p. xv.

[c] See especially Report of the Commissioner of Patents, Agriculture, 1854, p. 134. American Agriculturist, November 1, 1854, p. 120; January, 1857, p. 10; February, 1874, p. 63. Rural New Yorker, January 21, 1854, p. 22; January 21, 1858, p. 14. American Farmer, January, 1856, p. 57. The Cultivator, May 18, 1855.

accounts the Mammoth may well be the "white-seeded" soja bean obtained by the Perry expedition. The "red-seeded soja bean" was perhaps, the Adsuki bean (*Phaseolus angularis*), as no red-seeded soy bean is known.

Prof. G. H. Cook, of New Brunswick, N. J., obtained seed of the soy bean at the Bavarian Agricultural Station in 1878. In the same year Mr. James Neilson[a] obtained seeds of several varieties at Vienna, Austria. Both of these gentlemen planted the seeds and gathered crops of the different varieties in 1879. These varieties were without doubt those grown and distributed through Europe by Professor Haberlandt, of Vienna.

A yellow-seeded soy bean was grown at the North Carolina Agricultural Experiment Station in 1882 and reported on in some detail. The source of the variety is not given, but by implication it is the same as the variety stated to be grown by a number of persons in the State, and is probably the Mammoth.[b]

Two varieties, one black seeded, the other with white seeds, were grown at the Massachusetts Agricultural Experiment Station in 1888.[c]

In 1890 Prof. C. C. Georgeson secured three lots of soy beans from Japan which were grown at the Kansas Agricultural Experiment Station in 1890 and subsequently.[d]

Prof. W. P. Brooks, of Amherst, Mass., brought with him from Japan in 1889 a number of soy-bean varieties, including the Medium Green or Guelph, and the Ito San. It is quite certain that other importations of soy beans from Asia were made by others, but no definite records have been found.

Since 1890 most of the agricultural experiment stations have experimented with soy beans and many bulletins have been published dealing wholly or partly with the crop.

VARIETIES INTRODUCED INTO THE UNITED STATES INDEPENDENTLY OF THE DEPARTMENT OF AGRICULTURE OR PREVIOUS TO 1898.

ENUMERATION.

Previous to the numerous introductions by the United States Department of Agriculture beginning in 1898, there were not more than eight varieties of soy beans grown in the United States, namely, Ito San, Mammoth, and Butterball, with yellow seeds; Buckshot and Kingston, with black seeds; Guelph or Medium Green, with green seeds; and Eda and Ogemaw, with brown seeds.

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[a] Rural New Yorker, 1882, p. 9.

[b] Annual Report of the North Carolina Experiment Station, 1882, pp. 116-127.

[c] Annual Report of the Massachusetts Experiment Station, 1889, pp. 140-141.

[d] Bulletin 19, Kansas Agricultural Experiment Station, p. 200.

It has been possible to determine the history of these, in part at least, which is of value in interpreting the older records.

ITO SAN.

Ito San was among the varieties introduced in 1899 by Prof. W. P. Brooks, of Amherst, Mass., and by him called Early Yellow. Later, Mr. E. E. Evans secured seed of it and in 1902 called it Ito San. Mr. Evans writes that he subsequently secured it "from half a dozen sources in the United States and Japan." The same variety was also among those introduced by Prof. C. C. Georgeson, of the Kansas Agricultural Experiment Station, and grown in 1890 [a] and subsequent years. This conclusion is based on the identity of nine varieties obtained from the Rhode Island Agricultural Experiment Station in 1903. This station had previously obtained several varieties from the Kansas Agricultural Experiment Station in 1892.[b] Three of the varieties from Rhode Island had exactly the same names as those published in Bulletins 19 and 32 of the Kansas Agricultural Experiment Station, namely, Eda Mame, Yellow Soy Bean, and Kiyusuke Daidzu. All three of these are Ito San.

Ball [c] gives a list of numerous American sources through which this variety was secured under such names as Yellow, Early Yellow, and Early White. It was also grown at the Virginia Agricultural Experiment Station in 1905 as Japanese pea, as shown by later cultures at the Arlington Experimental Farm of seed from this experiment station.

Among the introductions of the Office of Foreign Seed and Plant Introduction it is represented by No. 6326, received in 1901 from Tokyo, Japan, and No. 21818, obtained from Vilmorin-Andrieux & Co., Paris, France, as "Yellow Etampes." It is quite probable that this is one of the varieties grown by Professor Haberlandt in his experiments, as all of his varieties were grown at Etampes and other places in France.[d] We suspect that this is also the variety that was distributed by the United States Patent Office in 1853, as most of the early accounts point to this or a closely similar variety. These accounts refer to it as Japan pea, Japanese pea, Japan bean, and also coffee berry.[e]

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[a] Bulletin 19, Kansas Agricultural Experiment Station, December, 1890.

[b] Report, Rhode Island Agricultural Experiment Station, 1892, p. 150.

[c] Bulletin 98, Bureau of Plant Industry, p. 24.

[d] La Nature, 1881, pt. 2, p. 115.

[e] See especially the Rural New Yorker, January 21, 1854, p. 22.

MAMMOTH.

The Mammoth is at present the most important soy bean grown in the United States. It has also been known as Late, Yellow, Late Yellow, Southern, and Mammoth Yellow.

The date of introduction of this variety is very obscure, and nothing definite is known regarding its origin. None of the numerous recent introductions are identical and but one is closely similar, namely, No. 22318, from Erfurt, Germany, received as "Yellow Riesen." It is not probable, though, that this was German-grown seed, as so late a variety could scarcely mature in Germany. Several varieties from Shanghai, China, and from Japan are closely related. It may possibly be the "white-seeded" soy bean introduced by the Perry expedition. We have been unable to find any early published records that definitely refer to this variety. It is not improbable that it is this variety that was grown at the North Carolina Agricultural Experiment Station in 1882. There can be but little doubt that it is the "soja" bean from T. W. Wood & Sons, Richmond, Va., grown by the Kansas Agricultural Experiment Station in 1889 [a] and in 1890.[b] Since 1895 Mammoth has been a well-known variety.

BUCKSHOT.

The history of this variety is somewhat complicated. It has been obtained from the following American sources:

Agrostology No. 1184, "Black," from Rhode Island Agricultural Experiment Station, spring, 1903.

Agrostology No. 1301, "Early," from Johnson & Stokes, March, 1902.

Agrostology No. 1303, "Extra Early Black," from J. M. Thorburn & Co., March, 1902.

Agrostology No. 1304, from W. A. Burpee, March, 1902.

Agrostology No. 1474, "Extra Early Black," from Hammond Seed Company, March, 1903.

Agrostology No. 2033, "Crossbred No. 9," from the Arkansas Agricultural Experiment Station, May, 1904. "Crossbred No. 9" of Evans is really Ogemaw, while his "Crossbred No. 6" is Early Black or Buckshot. These two numbers were exactly reversed at the Arkansas Experiment Station, as the variety received from that station as "Crossbred No. 6" (Agrostology No. 2031) proved to be Ogemaw.

All of the foregoing were later united as S. P. I. No. 17251.

S. P. I. No. 6334, from Tokyo, Japan, April 20, 1901. Among the progeny of this are S. P. I. Nos. 8491, 9412, and probably 11179, and Agrostology No. 1292.

S. P. I. No. 19987, from Yokohama, Japan, 1907.

S. P. I. No. 22883, from Tokyo, Japan, 1908.

S. P. I. No. 22322, "Early Black from Podolia," Haage & Schmidt, 1908.

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[a] Report, Kansas Agricultural Experiment Station, 1889, p. 43.

[b] Bulletin 19, Kansas Agricultural Experiment Station, p. 201.

From these data it would appear that the Buckshot is a common Japanese variety. But Mr. E. E. Evans, West Branch, Mich., claims that this variety was originated by him in 1901 as a hybrid "Evans's Crossbred No. 6," which he advertised in 1902 and distributed widely. In recent correspondence Mr. Evans states that this was a hybrid of a large, flat, black variety, Medium Early Black, and of the Dwarf Brown. According to Mr. Ball, No. 6334 and its progeny numbers were identical with Evans's variety. In Mr. H. T. Nielsen's opinion, Nos. 19987 and 22883 were also precisely identical. Unfortunately, these three Japanese lots were not grown in 1909. A critical comparison of the seed samples shows, however, that the three Japanese lots have thicker, more nearly globose seeds than most of the lots derived from Evans's plant. It is, therefore, not unlikely that there are really two closely similar but distinct varieties involved, a matter which needs further investigation.

Nos. 22322 and 25212 A are undoubtedly the same as Evans's plant.

GUELPH, OR MEDIUM GREEN.

Guelph, or Medium Green, was introduced by Prof. W. P. Brooks in 1889, from Japan, and is now quite extensively grown in the Northern States. The same variety was also obtained from Hankow, China, in May, 1901—S. P. I. No. 6558, according to Ball's identification.[a] It has since been received from only one foreign source, namely, S. P. I. No. 22320, from Haage & Schmidt, as "Green Samarow." This last might easily be the progeny of the American introduction.

BUTTERBALL.

The Butterball variety was first secured from the Rhode Island Agricultural Experiment Station in 1903 as "Early Japan," and it is probably one of Professor Brooks's introductions. According to Ball,[b] S. P. I. No. 8422, from Yokohama, Japan, is identical. A recent culture of this number obtained after a lapse of several years from the Illinois Agricultural Experiment Station, through Mr. H. B. Derr, proved to be Butterball, but there were a few different things intermixed, probably hybrids. A recent lot of seed from Dammann & Co., Naples, Italy, S. P. I. No. 22415, received as "Giant Yellow," is undoubtedly Butterball.

[a] Bulletin 98, Bureau of Plant Industry, p. 21.

[b] Bulletin 98, Bureau of Plant Industry, p. 25.

KINGSTON.

The Kingston soy bean was received from the Rhode Island Agricultural Experiment Station in 1903 as "Japanese No. 15." It was obtained by them from Prof. W. P. Brooks, of the Massachusetts Agricultural Experiment Station, who brought a number of soy-bean varieties from Japan in 1889, and is probably the variety which he named "Medium Black." It has never been secured from any other source. In all probability this is the variety grown at the Rhode Island Agricultural Experiment Station in 1893[a] as "Medium Black."

SAMAROW.

The Samarow has not occurred in any of our Asiatic importations. It is advertised under the name of "Green Samarow" by several European seedsmen. Messrs. J. M. Thorburn & Co., who first introduced it into the United States about 1901, inform us that their seed was from Italy. The "Green Samarow," S. P. I. No. 22320, from Haage & Schmidt, Erfurt, Germany, proved to be Guelph.

EDA.

The Eda is the brown-seeded variety introduced from Japan and grown by the Kansas Agricultural Experiment Station in 1890 under the name *Yamagata Cha-daidzu.* The identification of Chadaidzu rests on the fact that the Rhode Island Agricultural Experiment Station secured all of the varieties from Kansas in 1892. The Department of Agriculture obtained all of these varieties from Rhode Island in 1903, including but one brown-seeded variety under the name "Brown Eda Mame."

OGEMAW, OR OGEMA.

The Ogemaw, or Ogema, variety was first introduced by Mr. E. E. Evans, of West Branch, Mich., in 1902, as "Evans's Crossbred No. 9." Mr. Evans writes that he originated this as a cross between his No. 6, Early Black, and the Dwarf Brown. All of the several lots of this variety grown in our trials, namely, Agrostology Nos. 13502, 17258, and 17259, trace back to this origin, and it has been obtained from no foreign source. Nos. 21755, from France, and 25212, from Bremen, Germany, are very similar, however.

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[a] Annual Report, Rhode Island Agricultural Experiment Station, 1893, p. 191.

VARIETIES GROWN IN EUROPE.

EARLY HISTORY.

The growing of soy beans in Europe dates from the experiment of Prof. Friedrich Haberlandt, of Vienna, in 1875 and subsequen years. Haberlandt secured seed of nineteen varieties at the Vienn exposition in 1873. These were as follows:

Five yellow-seeded varieties from China.
Three black-seeded varieties from China.
Three green-seeded varieties from China.
Two brown-red-seeded varieties from China.
One yellow-seeded variety from Japan.
Three black-seeded varieties from Japan
One black-seeded variety from Trans Caucasia.
One green-seeded variety from Tunis.

Of these, only four varieties matured at Vienna, namely, tw yellow seeded, one black seeded, and one brown-red seeded, all fron China. All of Haberlandt's further work was done with these fou varieties, which were grown in many places in Austria and German and in France and Italy, so that they became widespread. Presum ably they are still among the varieties grown in Europe. The were brought to this country by Cook and by Neilson in 1878,[a] bu it is only by surmise that any of the American varieties can be trace to this source.

From various European sources the following varieties of so beans have been obtained:

SAMAROW.

Seed obtained from Dammann & Co., Naples, Italy, No. 22411, and identical with No. 17260, which last was introduced by Messrs. Thorburn & Co. from Italy. Als called "Green Samarow."

ETAMPES.

Seed from Vilmorin-Andrieux & Co., Paris, France, No. 21818, proved identical with Ito San. Also advertised by other European seedsmen, usually as Yellow Etampes.

CHERNIE.

Seed was received from Vilmorin-Andrieux & Co. as "Early Black from Podolia," No. 21757 and No. 21756; from Haage & Schmidt, Erfurt, Germany, as No. 22321; and from Dammann & Co. as "Black," No. 22412. All of these are identical and indistinguishable from No. 18227, obtained from Khabarovsk, Siberia.

"YELLOW RIESEN."

Seed obtained from Haage & Schmidt, No. 22318. The variety is very similar to Mammoth, but somewhat later. No. 22317, "Yellow," from the same source, has indistinguishable seeds, but these did not germinate.

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[a] Rural New Yorker, 1882, p. 9.

BUCKSHOT.

No. 22322, obtained from Haage & Schmidt, is indistinguishable from the Buckshot variety, S. P. I. No. 17251. It was received as "Early Black from Podolia," but is not the same as the variety received under that name from another source. Seeds of this variety were also mixed in the brown seed from the Botanical Garden of Bremen, Germany, and grown as No. 25212 A.

"YELLOW."

This variety was received from Dammann & Co., No. 22414, and Vilmorin-Andrieux & Co., No. 21754, the two being identical and different from any others yet received. It is a small, early variety, maturing at Arlington in ninety days.[a]

"BROWN."

Seed under this name was obtained from Dammann & Co., No. 22413, Haage & Schmidt, No. 22319, and Vilmorin-Andrieux & Co., No. 21755. These seeds are indistinguishable, but only No. 21755 grew. The original seed of this is much smaller than Ogemaw, but in 1909 both the seeds and plants could not be distinguished from Ogemaw from Michigan. No. 25212, from the Botanical Garden, Bremen, Germany, also with brown seeds, was likewise indistinguishable from Ogemaw in 1909, though the original seeds were different both from No. 21755 and from Ogemaw.

BUTTERBALL.

The variety secured from Dammann & Co., No. 22415, as "Giant Yellow," could not be distinguished from S. P. I. No. 17274, Butterball.

S. P. I. NO. 5039.

This seed was received from Vilmorin-Andrieux & Co. as "Extra Early Black Seeded." This is the original importation of the variety later named Wisconsin Black, S. P. I. No. 25468, which is now commercially handled by a few seedsmen.

There are no authentic records of a few of the earliest S. P. I. importations from Europe, so that nothing definite can be said as to their identity. Among these are No. 1492 (brown seeded), No. 1493 (black seeded), and No. 2156, Yellow Etampes, all from France.

From these data it would appear that at the present time at least ten varieties of soy beans are more or less grown in Europe. Presumably there are included among these the four varieties grown by Haberlandt, and it is therefore probable that his black variety was Chernie, his brown-red variety the "Brown" of the European seedsmen, one of the yellows the Ito San or Etampes, and the other probably the "Yellow" of Dammann & Co. and Vilmorin-Andrieux & Co. All of these are quite small seeded and agree well with the weights per thousand seeds as given by Haberlandt.

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[a] No. 17276, without name, from Havre, France, is a very similar but distinct variety.

THE SOY BEAN IN ASIA.

ASIATIC SOURCES OF SOY BEANS.

Soy beans are grown most abundantly in Asia in Japan, Korea Manchuria, and in the northern provinces of China, namely Shan-s and Shan-tung, but little detailed statistical information concernin the crop has yet been published.[a]

In other provinces of China the plant seems not to be cultivate extensively, though grown as far south as the Yangtse. Seeds hav also been received from such places as Canton and Hongkong i southern China, but it is not certain that these were grown there The soy bean is also grown sparingly in Formosa, Cochin China Celebes, Java, and India.

According to Watt[b] the soy bean is "extensively cultivate throughout India and in eastern Bengal, Khasi Hills, Manipur, th Naga Hills, and Burma, often found as a weed on fields or near culti vation." The few varieties secured from India are very distinct indicating a long culture in that country, as indeed the numerou vernacular names used would imply.

LIST OF VARIETIES.

Among the many varieties introduced it is a very interesting fac that the same variety has rarely been secured a second time unles from the same place. It appears that practically every locality i China has its own local varieties. If this be true, then there ar probably several times as many varieties existing as have yet bee obtained. In general, the earliest varieties come from the northern most localities, the latest from the southernmost.

The following lists show the various places in Asia from whicl soy-bean seed has been obtained. Distinct soy-bean varieties ar obtained from practically every different locality. The list not only indicates to some extent the distribution of the soy bean, but will suggest the more likely regions from which valuable new varietie may be obtained.

SIBERIA.

South Usuri, Nos. 480, 20699; Khabarovsk, Nos. 18227, 20405, 20406, 20408; Mer- koechofka, Nos. 20407, 20409, 20410, 20411, 10412, 20414.

MANCHURIA.

Newchwang, Nos. 19183, 19184, 19186; Harbin, No. 20854; Tieling, Nos. 21079, 21080.

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[a] See, however, the following works: Hosie, Alexander, Report on the Province of Szechwan, 1904, and Soya Bean and Products; Special Consular Reports, vol. 40, 1909, Bureau of Manufactures, Department of Commerce and Labor.

[b] Dictionary of the Economic Products of India, 1890, vol. 3, p. 510.

KOREA.

Pingyang, Nos. 6386, 6396, 6397, 6414, 6416; Ko-bau, No. 20011.

JAPAN.

Tokyo, Nos. 647, 648, 650, 651, 652, 653, 654, 655, 656, 6312, 6314, 6326, 6333, 6334, 35, 6336, 22874, 22875, 22876, 22877, 22878, 22879, 22880, 22881, 22882, 22883, 22884, 885; Kobe, Nos. 20892, 20893; Yokohama, Nos. 4980, 8422, 8423, 8424, 19981, 19982, 83, 19984, 19985, 19986, 19987, 22503, 22504, 22505, 22506, 22507; Hokkaido, Nos. 825, 21830, 21831; Anjo, No. 8900.

CHINA.

Peking, Chihli, Nos. 17852, 23305, 23306, 27498; Shan-hai-kwan, Chihli, No. 17857; ientsin, Chihli, Nos. 17862, 23229; Paotingfu, Chihli, Nos. 22897, 22899, 22900, 901, 23312; Wutaishan, Chihli, Nos, 23291, 23292; Shiling, Chihli, Nos. 23303, 311; Pee-san, Chihli, No. 18258; Tschang-ping-tsu, Chihli, No. 18259; Sachon, hihli, No. 17861; Chefoo, Shantung, Nos. 22536, 22537, 22538; Boshan, Shantung, No. 899; Chungking, Szechwan, Nos. 23522, 23523; Ningyuenfu, Szechwan, Nos. 544, 23545, 23646; Yachow, Szechwan, Nos. 25437, 25438; Soochow, Kiangsu, Nos. 207, 24180, 24181, 24182, 24183, 24184, 25133, 25134, 25135, 25136, 25137, 25138; anghai, Kiangsu, Nos. 14952, 14953, 14954, 18619, 22311, 22312, 22927, 23205, 23336, 337, 23338; Chinhuafu, near Shanghai, Nos. 20797, 20798, 23232; Chin-kiang, iangsu, Nos. 8584, 8586; Chinhua, Kiangsu, No. 9344; Tangsi, Chekiang, Nos. 23208, 209, 23211; Taichow, Chekiang, Nos. 23296, 23297; Hangchow, Chekiang, Nos. 16789, 790, 22498, 22499, 22500, 22501, 22644, 22645, 22646, 23212, 23213; Hankow, Hupeh, os. 6556, 6558, 6559, 6560, 6561; Wuchang, Hupeh, Nos. 2869, 2870, 2871, 2872; gchung, Fukien, Nos. 22920, 22921, 22922; Ingang, Fukien, No. 27499; Swatow, wangtung, No. 22886; Canton, Kwangtung, Nos. 22379, 22380, 23325, 23326, 23327; ongkong, Kwangtung, Nos. 22406, 22407; Sheklung, Kwangtung, Nos. 22633, 22634; intse, Anhwei, No. 23299; Weihsien, Shantung, Nos. 22534, 22535.

FORMOSA.

Taihoku, Nos. 24641, 24642, 24643.

COCHIN CHINA.

Saigon, No. 22714.

INDIA.

Darjiling, Assam, Nos. 24673, 24674; Pithoragarh, Kumaon District, No. 25118; hasi Hills, Assam, No. 24672; Safipur, Unao, U. P., No. 24675; Hasangani, Unao, U. P., No. 24676; Ranjitpurwa, Unao, U. P., No. 24677; Etawah, U. P., Nos. 24678, 679, 24680, 24683, 24684, 24685, 24686; Mainpuri, U. P., Nos. 24681, 24682; United rovinces, No. 24687; Cawnpore, U. P., Nos. 24688, 24689; Dehra Dun, U. P., No. 690; Poona, Bombay, but grown there from Japanese seed, Nos. 24693, 24694, 695, 24696, 24697, 24698, 24699, 24700, 24701, 24702, 24703, 24704, 24705, 24706, 707, 24708, 24709, 24710, 24711.

JAVA.

Buitenzorg, No. 21946.

CELEBES.

Macassar, Celebes, No. 5517.

DESIRABLE CHARACTERS IN SOY-BEAN VARIETIES.

CONSIDERATIONS GOVERNING CHOICE.

The determination of the best variety of soy bean for any locality will depend first on whether it is grown primarily for hay or for grain, or for both purposes. In this, as with other crops, yield is the most valuable single desideratum. Secondary considerations of importance are habit of the plant, degree of coarseness, ability to retain the foliage, color of seed, and ease of shattering.

HABIT OF THE PLANT.

Erectness of stem with upright or ascending branches is a prime requisite of a desirable variety. A tall habit is also important, as dwarf varieties usually bear pods very close to the ground, so that many will be left on the stubble, which is not the case in many tall sorts.

COARSENESS.

An objection to some varieties of soy beans is the coarse, woody stem which makes mowing difficult. There are many slender varieties where this objection does not hold, but slenderness is usually accompanied with small pods and seeds, and often with vining tips and a tendency to lodge. Unless there is lodging, such varieties are easily mown.

ABILITY TO RETAIN LEAVES.

Nearly all soy beans begin to shed their leaves as the pods ripen. There are a number of exceptions to this, like the Wisconsin Black, where the leaves remain green even after all the pods are mature. It may be possible to combine this character as a valuable feature to later varieties to be grown both for hay and grain.

COLOR OF THE SEED.

Yellow or green seeds are preferable to darker colors, as the shattered seeds are more easily found by hogs pasturing the field or stubble.

SHATTERING.

When grown for grain alone, shattering is a serious fault. Some varieties, like Guelph, shatter inordinately; others, like Peking, scarcely at all; while most varieties shatter somewhat, especially during changeable weather, if not harvested when ripe. As a rule the varieties with large pods and seeds shatter much worse than those with small pods and seeds. In a few varieties, like Brownie, the seed coats break badly in thrashing, a very objectionable character.

RESISTANCE TO DISEASE.

In sections where nematodes and cowpea wilt occur most soy-bean varieties are seriously affected by both these diseases. A few varieties, however, exhibit considerable resistance to these diseases, and there is good ground to believe that practically immune strains can be developed.

NONFILLING OF PODS.

In Louisiana and the southern half of Alabama, Mississippi, and Georgia late varieties of soy beans, especially the Mammoth, frequently fail to develop seeds, while earlier sorts are not thus affected. The cause for this has not been determined. At Biloxi, Miss., selections of No. 20797 fill their pods perfectly, so that there is little doubt that late varieties adapted to this section can be secured or developed.

SYNOPSIS OF THE GROUPS.

Plants bushy, the branches without tendency to twine, the terminals rarely elongated:
- Pods medium to large, crowded or scattered; stems coarse to medium. GROUP I
- Pods small, stem rather slender—
  - Internodes short, the pods crowded; medium late................ II
  - Internodes long, the pods scattered; very late; foliage dark green. III

Plants more or less twining, especially the long, slender terminals:
- Plants erect or suberect, slender, the internodes long; pods medium to small.......... IV
- Plants procumbent, rather coarse; pods small; very late............... V

These groups merge into each other more or less, but in a general way represent fairly distinct types. The type of branching is the same in all, the differences being due to the relative development of the main stem and the lateral branches.

SYNOPSIS OF THE VARIETIES.

GROUP I.—190 VARIETIES.

Group I contains far more than half of the varieties of soy beans, including all the best known ones, such as Mammoth, Hollybrook, Guelph, and Ito San.

Seeds straw-yellow; germ yellow—71 varieties.—Nos. 14953, 14953 A, 14953 B, 16790 D, 17257 E, 17262 B, 17268, 17268 A, 17269, 17269 D, 17270, 17271, 17273, 17275, 17275 L, 17276, 17277, 17277 A, 17278, 17280, 17862 G, 18619, 19184 A, 19184 G, 19981, 19981 A, 19984, 20011 A, 20406, 20406 C, 20407 B, 20892, 20892 A, 20893 A, 21079 H, 21080 K, 21754, 21825, 22312, 22318, 22318 A, 22335, 22379, 22406, 22498, 22503, 22504 A, 22505, 22506, 22714, 22876, 22879, 22880, 22880 A, 22880 C, 22901, 22921 B, 22922, 22922 A, 23207 B, 23209, 23292, 23296, 23303, 24181, 24672, 24672 B, 24695, 24840, 25131, 27500.

Seeds olive-yellow; germ yellow—45 varieties.—Nos. 17251 A, 17253 C, 17254 C, 17262 17263, 17263 D, 17264, 17267, 17268 C, 17271 E, 17275 B, 17862 E, 19184 D, 19184 E 19186, 19981 B, 19984 D, 19985, 19985 F, 19985 K, 19986, 20011, 20405, 20405 C, 20406 E, 20798 C, 21079, 21079 D, 22381, 22381 B, 22504, 22507, 22537, 22644, 22644 B 22644 C, 22645, 22646, 22874, 22898 A, 22920, 23207, 24183, 24839, 27501.

Seeds chromium green; germ green—17 varieties.—Nos. 17260, 17261, 17271 L, 17852 N, 17862 B, 18258 E, 20854, 21080, 21080 N, 22500, 22880 B, 22897, 23209 A, 23292 C, 23296 A, 23303 A, 25437 A.

Seeds brown to olive; germ yellow—28 varieties.—Nos. 17254 B, 17256, 17257, 17257 D, 17257 G, 17258, 17258 A, 17260 B, 17263 C, 17277 C, 17277 D, 18258 N, 19186 C, 19984 A, 19984 B, 20405 B, 20406 G, 20412 A, 20412 B, 21080 L, 21755, 22333, 22411 A, 22644 A, 23229, 24610, 25130, 25437 C.

Seeds black; germ yellow—18 varieties.—Nos. 17251, 17252, 17252 C, 17253, 17254, 17262 D, 17271 D, 20410, 22634, 23205, 23292 A, 23296 C, 23325, 23523, 23546, 24180, 24682, 25468.

Seeds black; germ green—7 varieties.—Nos. 14952, 17255, 19184, 21079 A, 22336 A, 23306, 25437 B.

Seeds bicolored; germ yellow—4 varieties.—Nos. 20407, 20411, 23213 A, 23311 B.

GROUP II.—4 VARIETIES.

Group II consists of four varieties which appear very promising as grain producers. The small size of the seeds is not objectionable, but on the contrary advantageous when grown for grain alone.

Seeds olive-yellow; germ yellow—2 varieties.—Nos. 17852 E, 23312.

Seeds black; germ yellow—2 varieties.—Nos. 17852 B, 23311 A.

GROUP III.—3 VARIETIES.

The four or five varieties belonging to Group III have a very different appearance from other soy beans. They all come from the valley of the Yangtse, and are said to be grown on the low-lying rice fields either as a green manure or for fodder. Their marked leafiness, large size, and slender stems make them especially desirable for hay. They are too late to mature at Washington.

Seeds brown to olive; germ yellow—3 varieties.—Nos. 9344, 20798, 23336.

Seeds black; germ yellow—3 varieties.—Nos. 6560, 20797, 23337.

Seeds bicolored; germ yellow—2 varieties.—Nos. 6559, 23338.

GROUP IV.—76 VARIETIES.

Group IV is the second largest group and includes the most important Manchurian varieties. From the standpoint of seed production, they promise to be superior to Group I because of their relatively slender stems, permitting easy mowing, and their smaller pods and seeds, which shatter less easily. They can also be planted more closely because they are less bushy.

Seeds straw-yellow; germ yellow—25 varieties.—Nos. 14954, 16789, 16789 A, 16789 B, 17272, 17277 E, 17862, 17862 C, 17862 F, 18258, 18258 A, 19186 F, 22534, 22921, 22921 A, 23208, 23213, 23297 B, 24184, 25133, 25134, 25134 A, 25437, 25438 B, 27499.

Seeds olive-yellow; germ yellow—8 varieties.—Nos. 17857 B, 19183 B, 19184 C, 20798 E, 21999 C, 21999 D, 22633, 22920 A.

Seeds chromium green; germ green—7 varieties.—Nos. 17857, 18258 D, 23311, 25135, 25438, 25438 A, 27498.

Seeds brown to olive; germ yellow—12 varieties.—Nos. 17852 C, 19186 D, 20409, 20412, 21999 B, 23211, 23232, 23292 B, 23297 A, 23299, 24672 A, 25136.

Seeds black; germ yellow—16 varieties.—Nos. 16790, 16790 B, 17852 D, 17852 R, 17861, 18227, 18259, 19183, 19186 B, 22538, 22899, 22899 A, 22919, 23291, 23297, 23338 B.

Seeds black; germ green—5 varieties.—Nos. 22380, 22407, 22501, 22900, 22927.

Seeds bicolored; germ yellow—3 varieties.—Nos. 17852, 21999, 23299.

GROUP V.—7 VARIETIES.

The varieties included in Group V are mostly from India, but the wild soy bean of China and Japan is also included. All form tangled masses of vines, difficult to mow, but perhaps of use as green manure and pasture crops.

Seeds straw-yellow; germ yellow—1 variety.—No. 24674.

Seeds brown to olive; germ yellow—1 variety.—No. 24673.

Seeds shining black; germ yellow—3 varieties.—Nos. 24642, 24675, 25137.

Seeds dull black, very small; germ yellow—1 variety.—No. 22428.

Seeds bicolored: germ yellow—1 variety.—No. 25118.

CATALOGUE OF SOY-BEAN VARIETIES.

The following is a complete list of soy beans imported by the United States Department of Agriculture, arranged chronologically in accordance with the serial numbers (S. P. I. numbers) assigned to them by the Office of Foreign Seed and Plant Introduction:

480. From South Usuri, Siberia, 1898. Seeds yellow. Insufficient varietal notes.

647. From Tokyo, Japan, 1898. Insufficient varietal notes.

648. From Tokyo, Japan, 1898. Insufficient varietal notes.

649. From Tokyo, Japan, 1898. Insufficient varietal notes.

650. From Tokyo, Japan, 1898. Insufficient varietal notes.

651. From Tokyo, Japan, 1898. Insufficient varietal notes.

652. From Tokyo, Japan, 1898. Insufficient varietal notes.

653. From Tokyo, Japan, 1898. Insufficient varietal notes.

654. From Tokyo, Japan, 1898. Insufficient varietal notes.

655. From Tokyo, Japan, 1898. Insufficient varietal notes.

656. From Tokyo, Japan, 1898. Insufficient varietal notes.

1492. From France, 1898. Seed brown. Insufficient varietal notes.

1493. From France, 1898. Seed black. Insufficient varietal notes.

2156. From France, 1898. "Yellow Etampes." See 17268.

2869. From Wuchang, Hupeh, China, 1899. Seeds yellow. Insufficient varietal notes.

2870. From Wuchang, Hupeh, China, 1899. Seeds green. Insufficient varietal notes.

2871. From Wuchang, Hupeh, China, 1899. Seeds green. Insufficient varietal notes.

2872. From Wuchang, Hupeh, China, 1899. Seeds green. Insufficient varietal notes.

3869. From China, 1899. Insufficient varietal notes.
3870. From China, 1899. See 17272.
3884. From Honolulu, 1899. Seeds yellow. Insufficient varietal notes.
3885. From Honolulu, 1899. Seeds black. Insufficient varietal notes.
3886. From Honolulu, 1899. Seeds green. Insufficient varietal notes.
4285. From Richmond, Va., 1900. "Mammoth." See 17280.
4628. From Amherst, Mass., 1900. "Medium Green." See 17261.
4912. From Japan. See 17270.
4913. From Japan. See 12400.
4914. From Japan. See 17266.
4980. From Yokohama, Japan. Insufficient varietal notes.
5039. From Paris, France. See 25468.
5517. From Macassar, Celebes. Insufficient varietal notes.
5764. Grown from 4912. See 17270.
5765. Grown from 4913. See 12400.
5766. Grown from 4914. See 17266.
6312. From Tokyo, Japan, 1901. See 17252.
6314. From Tokyo, Japan, 1901. See 17262.
6326. From Tokyo, Japan, 1901. See 17268.
6333. From Tokyo, Japan, 1901. See 17277.
6334. From Tokyo, Japan, 1901. See 9412.
6335. From Tokyo, Japan, 1901. See 17267.
6336. From Tokyo, Japan, 1901. See 9413.
6379. Grown from 3870. See 17272.
6386. From Pingyang, Korea, 1901. See 17254.
6396. From Pingyang, Korea, 1901. See 17271.
6397. From Pingyang, Korea, 1901. See 17263.
6414. From Pingyang, Korea, 1901. See 17256 and 22333.
6416. From Pingyang, Korea, 1901. See 17253.
6556. From central China. See 17269.
6558. From Hankow, Hupeh, China. See 17261.
6559. *Hankow.* From near Hankow, Hupeh, China, 1901. Plants slender, erect, very leafy; height 36 to 42 inches; very late; pubescence tawny; flowers purple; pods scattered; seeds brown, more or less banded with black, medium small, oblong, flattened; hilum brown; germ yellow. This variety is almost identical with the following, except for the color of the seed.
6560. *Riceland.* From near Hankow, Hupeh, China. Plants slender, erect, very leafy; height 36 to 60 inches; very late; pubescence tawny; flowers purple; pods scattered; seeds black, oblong, small, flattened; hilum pale; germ yellow. This is very similar to 20797, but has smaller seeds. The stock has been lost.
6561. From near Hankow, Hupeh, China. Seeds small, black, short, oblong; medium small; hilum pale; germ yellow. Apparently it was never grown.
8422. From Yokohama, Japan. See 17274.
8423. From Yokohama, Japan. See 17265.
8424. From Yokohama, Japan. See 17264.
8489. Grown from 6314. See 17262.
8490. Grown from 6333. See 17277.
8491. Grown from 6334. See 9412.
8492. Grown from 6386. See 17254.
8493. Grown from 6396. See 17271.
8494. Grown from 6336. See 9413.

8495. Grown from 6397. See 17263.
8496. Grown from 6416. See 17253.
8497. Grown from 6312. See 17252.
8584. From Chin-kiang, Kiangsu, China. Insufficient varietal notes.
8586. From Chin-kiang, Kiangsu, China. Insufficient varietal notes.
8900. From Anjo, Japan. Insufficient varietal notes.
9344. From Chin-hua, Kiangsu, China. The seed of this did not germinate. It is almost certainly the same as No. 23336.
9407. Grown from 4912. See 17270.
9408. Grown from 4913. See 12400.
9409. Grown from 4914. See 17266.
9410. Grown from 6312. See 17252.
9411. Grown from 6333. See 17277.
9412. Grown from 6334. According to Ball, indistinguishable from several other lots, all of which were united as 17251, which see.
9413. Grown from 6336. According to Ball, identical with 12400, the two being united as No. 17275, which see.
9414. Grown from 6386. See 17254.
9415. Grown from 6396. See 17271.
9416. Grown from 6397. See 17263.
9417. Grown from 6414. See 17256.
9417 A. Grown from 6414. See 22333.
9418. Grown from 6416. See 17253.
11179. Origin lost. Same as 17251.
11180. Origin lost. Insufficient varietal notes.
12399. Grown from 9407. See 17270.
12400. Grown from 9408. According to Ball, this proved identical with 9413, the seed of these two numbers being united as No. 17275, which see.
13502. *Ogemaw*. From West Branch, Mich. See 17258.
13503. *Guelph*. Grown at Arlington Experimental Farm from seed from Thorburn & Co. See 17261.
14952. *Shanghai*. From Shanghai, China, 1905. Erect, stout, bushy; height 30 to 36 inches; late; pubescence tawny; flowers both purple and white; pods large, 2¼ to 2½ inches long, tumid, scattered, shattering little; seeds black, large, 8 to 8½ mm. long, elliptical; hilum pale; germ green. Grown five seasons. No. 22311, also from Shanghai, proved to be the same.
14953. *Edward*. From Shanghai, China, 1905. Plants stout, erect, bushy; height 36 to 42 inches; very late; pubescence gray; flowers purple; pods large, 2 to 2½ inches, compressed, scattered, shattering little; seeds straw-yellow, large, 8 to 9 mm. long, elliptical, slightly flattened; hilum brown; germ yellow. Grown five seasons.
14953 A. A field selection in 1907. Plants stout, erect, bushy; height 30 to 36 inches; late; pubescence tawny; flowers purple; pods large, 2 to 2½ inches long, compressed, half crowded, shattering little; seeds straw-yellow, large, 8½ to 9 mm. long, elliptical, slightly flattened; hilum seal-brown; germ yellow. Grown two seasons.
14953 B. A field selection in 1907. Plants stout, erect, bushy; height 30 to 40 inches; very late; pubescence gray; flowers purple; pods large, 2¼ to 2½ inches long, tumid, scattered, shattering little; seeds straw-yellow, large, 8 to 8½ mm. long, elliptical, much flattened; hilum seal-brown; germ yellow. Grown two seasons.

14954. *Acme.* From Shanghai, China, 1905. Plants slender, erect, the tips twining; height 36 to 42 inches; late; pubescence gray (50 per cent) and tawny (50 per cent); flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, compressed, scattered, shattering little; seeds straw-yellow, small, 6½ to 7 mm. long, elliptical, slightly flattened; hilum seal-brown; germ yellow. Grown five seasons.

15887. From Chekiang Province, China. Indistinguishable from Riceland, 20797. Grown in 1907.

16789. *Brooks.* From Hangchow, Chekiang, China, 1905. Plants slender, erect, the tips twining; height 36 to 42 inches; medium late; pubescence gray; flowers both purple and white; pods medium-sized, 1¾ to 2 inches long, tumid, scattered, shattering little; seeds straw-yellow, medium-sized, 7½ to 8 mm. long, elliptical, slightly flattened; hilum light to dark brown; germ yellow. Grown four seasons. This is said to be the bean-cake bean grown so extensively in the Manchurian provinces and is a most valuable crop.

16789 A. *Flava.* A field mass selection in 1907. Plants slender, erect, the tips twining; height 28 to 34 inches; medium late; pubescence tawny; flowers both purple and white; pods medium-sized, 1¾ to 2 inches long, compressed, half crowded, shattering little; seeds straw-yellow, medium-sized, 8 to 8½ mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown two seasons.

16789 B. A field mass selection in 1907. Plants slender, erect, the tips twining; height 36 to 42 inches; late; pubescence tawny; flowers both purple and white; pods medium-sized, 1½ to 2 inches long, tumid, scattered, shattering little; seeds straw-yellow, medium large, 8 to 8½ mm. long, elliptical, slightly flattened; hilum light; germ yellow. Grown two seasons.

16790. *Cloud.* From Hangchow, Chekiang, China, 1905. Plants slender, erect, the tips twining; height 34 to 40 inches; medium late; pubescence both gray and tawny; flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, compressed, scattered, shattering little; seeds black, medium small, 7 to 7½ mm. long, oblong, much flattened; hilum pale; germ yellow. Grown four seasons. This variety is said to be an excellent table bean. No. 22535, from Weihsien, China, is the same thing.

16790 B. A field mass selection in 1907. Plants erect, the tips twining; height 48 to 52 inches; medium late; pubescence gray (10 per cent) and tawny (90 per cent); flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, compressed, scattered, shattering little; seeds dull black, medium-sized, 8 to 8½ mm. long, oblong, much flattened; hilum seal-brown; germ yellow. Grown two seasons.

16790 D. A pure field selection in 1907. Plants erect, stout, bushy; height 20 to 24 inches; medium late; pubescence gray; flowers purple; pods medium-sized, 1½ to 1¾ inches long, tumid, crowded, shattering little; seeds straw-yellow, medium-sized, 7½ to 8 mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown two seasons.

17251. *Buckshot.* Plants stout, erect, bushy; height 14 to 18 inches; early; pubescence tawny; flowers white; pods medium to large, 1½ to 2 inches long, crowded, shattering little; seeds black, large, 8 to 8½ mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown eight seasons. Buckshot has been on the market for a number of years and sold as Black, Early Black, Medium Early Black, Extra Early Black, Large Black, etc. No. 17251 is composed of the progeny of 6334 combined with various other lots. See page 29. Nos. 19987 and 22883 from Japan are very closely similar, if not identical.

17251 A. A pure field selection in 1907. Plants stout, erect, bushy; height 20 to 24 inches; medium; pubescence tawny; flowers purple; pods large, 1¾ to 2 inches long, tumid, half crowded, shattering little; seeds olive-yellow, medium large, 7½ to 8 mm. long, elliptical, slightly flattened; hilum black; germ yellow. Grown two seasons.

17252. *Flat King.* The progeny of 6312 from Tokyo, Japan, 1901. Plants stout, erect, bushy; height 24 to 30 inches; late; pubescence tawny; flowers white; pods large, 2¼ to 2½ inches long, compressed, half crowded, shattering little; seeds black, large, 11 to 11½ mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown nine seasons. This variety was also obtained from Yokohama, Japan, No. 19982, and again from Tokyo, No. 22875.

17252 C. A field mass selection in 1907. Plants stout, erect, bushy; height 30 to 36 inches; late; pubescence tawny; flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, tumid, half crowded, shattering little; seeds black, medium small, 6 to 6½ mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown two seasons.

17253. *Nuttall.* The progeny of 6416 from Pingyang, Korea, 1901. Plants stout, erect, bushy; height 18 to 24 inches; medium; pubescence tawny; flowers white; pods medium large, 1¾ to 2¼ inches long, crowded, shattering little; seeds black, medium-sized, 7½ to 8 mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown nine seasons. No. 22334 is undoubtedly the progeny of 17253 as shown by records.

17253 C. A field mass selection in 1907. Plants stout, erect, bushy; height 12 to 16 inches; medium late; pubescence tawny; flowers both purple and white; pods medium large, 2 to 2½ inches long, tumid, half crowded, shattering moderately; seeds olive-yellow, medium-sized, 7½ to 8 mm. long, oval; hilum black; germ yellow. Grown two seasons.

17254. *Ebony.* The progeny of 6386 from Pingyang, Korea, 1901. Plants stout, erect, bushy; height 22 to 26 inches; medium late; pubescence tawny; flowers purple; pods medium-sized, 1½ to 1¾ inches long, half crowded, shattering moderately; seeds black, medium small, 7 to 7½ mm. long, oblong, much flattened; hilum pale; germ yellow. Grown nine seasons. This variety was also received from Swatow, China, 1908 (S. P. I. No. 22886). Ebony has proved a valuable variety in southern Illinois and especially through the work of Mr. Ralph Allen, of Delavan, Ill., has become well known as No. 9414 and also as "Black Beauty."

17254 B. A pure field selection in 1907. Plants stout, erect, bushy; height 32 to 36 inches; medium late; pubescence gray; flowers purple; pods medium-sized, 1¼ to 1½ inches long, tumid, half crowded, shattering little; seeds cinnamon brown, small, 5½ to 6 mm. long, subglobose; hilum pale; germ yellow. Grown two seasons.

17254 C. A pure field selection in 1907. Plants stout, erect, bushy; height 20 to 26 inches; medium; pubescence tawny; flowers purple; pods medium-sized, 1½ to 1¾ inches long, compressed, half crowded, shattering moderately; seeds olive-yellow, medium-sized, 7½ to 8 mm. long, elliptical, much flattened; hilum clove-brown; germ yellow. Grown two seasons.

17255. *Kingston.* "Japanese Number 15" from Rhode Island Agricultural Experiment Station, originally from Japan. Plants stout, bushy, erect; height 16 to 22 inches; medium late; pubescence tawny; flowers white; pods small, 1¼ to 1½ inches long, tumid, crowded, shattering little; seeds black, small, 5½ to 6 mm. long, subglobose; hilum pale; germ green. Grown nine seasons. See also page 31.

17256. *Brownie*. The progeny of 6414 from Pingyang, Korea, 1901. Plants stout, erect, bushy; height 20 to 30 inches; medium late; pubescence gray; flowers purple; pods small, $1\frac{1}{8}$ to $1\frac{1}{2}$ inches long, tumid, crowded, shattering little; seeds cinnamon brown, small, 5 to $5\frac{1}{2}$ mm. long, subglobose; hilum pale; germ yellow. Grown nine seasons.

17256 A. *Baird*. See 22333.

17257. *Eda*. From Rhode Island Agricultural Experiment Station, 1903, but originally introduced by the Kansas Agricultural Experiment Station in 1890 as *Yamagata Cha-daidzu*. Plants stout, erect, bushy; height 14 to 20 inches; medium; pubescence tawny; flowers white; pods medium-sized, $1\frac{3}{4}$ to 2 inches long, tumid, half crowded, shattering moderately; seeds deep brown, large, $8\frac{1}{2}$ to 9 mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown nine seasons. See also page 31.

17257 D. A field mass selection in 1907. Plants stout, erect, bushy; height 20 to 26 inches; medium; pubescence tawny; flowers both purple and white; pods medium small, $1\frac{1}{4}$ to $1\frac{1}{2}$ inches long, tumid, half crowded, shattering moderately; seeds seal-brown, medium-sized, $6\frac{1}{2}$ to 7 mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown two seasons.

17257 E. A field mass selection in 1907. Plants stout, erect, bushy; height 18 to 22 inches; medium; pubescence tawny; flowers both purple and white; pods medium-sized, $1\frac{1}{2}$ to $1\frac{3}{4}$ inches long, tumid, half crowded, shattering moderately; seeds straw-yellow, medium-sized, 8 to $8\frac{1}{2}$ mm. long, elliptical, slightly flattened; hilum dark brown; germ yellow. Grown two seasons.

17257 G. A field mass selection in 1907. Plants stout, erect, bushy; height 20 to 26 inches; medium late; pubescence gray; flowers both purple and white; pods medium-sized, $1\frac{1}{2}$ to $1\frac{3}{4}$ inches long, tumid, half crowded, shattering little; seeds buff, medium-sized, 6 to $6\frac{1}{2}$ mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown two seasons.

17258. *Ogemaw*. The progeny of 13502 from E. E. Evans, West Branch, Mich., 1904. Plants stout, erect, bushy; height 18 to 22 inches; medium; pubescence tawny; flowers white; pods large, 2 to $2\frac{1}{4}$ inches long, tumid, crowded, shattering badly; seeds deep brown, large, $8\frac{1}{2}$ to 9 mm. long, elliptical, much flattened; hilum pale; germ yellow. Compare also page 31 and see notes under Nos. 21755 and 25212.

17258 A. A pure field selection in 1907. Plants stout, erect, bushy; height 20 to 24 inches; medium early; pubescence gray; flowers white; pods medium-sized, $1\frac{3}{4}$ to 2 inches long, tumid, half crowded, shattering little; seeds buff-brown, medium-sized, 7 to $7\frac{1}{2}$ mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown two seasons.

17260. *Samarow*. From J. M. Thorburn & Co., 1902. Plants stout, erect, bushy; height 15 to 18 inches; medium; pubescence gray; flowers purple; pods medium-sized, $1\frac{1}{2}$ to $1\frac{3}{4}$ inches long, tumid, half crowded, shattering little; seeds chromium green, medium-sized, 7 to $7\frac{1}{2}$ mm. long, elliptical, much flattened; hilum brown; germ green. Grown nine seasons. This variety has not occurred in any of our Asiatic importations. It is advertised under the same name by German and Italian seedsmen, and such an importation, No. 22411, from Italy, proved identical with 17260. See also page 31.

17260 B. A pure field selection in 1907. Plants stout, erect, bushy; height 14 to 18 inches; medium; pubescence gray; flowers purple; pods medium large, 2⅛ to 2¼ inches long, compressed, crowded, shattering moderately; seeds clove brown to almost black, medium-sized, 9 to 9½ mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown two seasons.

17261. *Guelph.* From J. M. Thorburn & Co., 1902. Plants stout, erect, bushy; height 20 to 24 inches; medium; pubescence tawny; flowers purple; pods medium-sized, 1½ to 1¾ inches long, tumid, half crowded, shattering much; seeds chromium green, medium to medium large, 7 to 8 mm. long, elliptical, slightly flattened; hilum brown; germ green. Grown eight seasons. This variety is advertised by a German seedsman, and such an importation, No. 22320, proved identical with 17261. According to Ball, No 6558 from Hankow, China, is the same as Guelph. Compare page 30.

17262. *Yosho.* The progeny of 6314 from Tokyo, Japan, 1901. Plants stout, erect, bushy; height 22 to 26 inches; medium; pubescence tawny; flowers purple; pods medium-sized, 1¾ to 2 inches long, tumid, half crowded, shattering little; seeds olive-yellow, large, 7½ to 8 mm. long, elliptical, slightly flattened; hilum black; germ yellow. Grown nine seasons.

17262 B. A pure field selection in 1907. Plants stout, erect, bushy; height 10 to 14 inches; medium early; pubescence tawny; flowers white; pods medium-sized, 1½ to 1¾ inches long, tumid, half crowded, shattering little; seeds straw-yellow, medium-sized, 7 to 7½ mm. long, elliptical, slightly flattened; hilum light brown; germ yellow. Grown two seasons.

17262 D. A field mass selection in 1907. Plants stout, erect, bushy; height 18 to 24 inches; medium; pubescence tawny; flowers both purple and white; pods medium-sized, 1¾ to 2 inches long, tumid, half crowded, shattering moderately; seeds black, medium large, 8 to 8½ mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown two seasons.

17263. *Austin.* The progeny of 6397 from Pingyang, Korea, 1901. Plants stout, erect, bushy; height 32 to 36 inches; late; pubescence gray; flowers both purple and white; pods medium-sized, 1¾ to 2 inches long, tumid, half crowded, shattering little; seeds olive-yellow, medium large, 8 to 8½ mm. long, elliptical, slightly flattened; hilum brown; germ yellow. Grown nine seasons. This variety was also distributed under Agrostology No. 1539.

17263 C. A field mass selection in 1907. Plants stout, erect, bushy; height 30 to 34 inches; medium late; pubescence gray; flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, tumid, half crowded, shattering little; seeds buff, medium small, 6½ to 7 mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown two seasons.

17264. *Tokyo.* The progeny of 8424 from Tokyo, Japan, 1901. Plants stout, erect, bushy; height 30 to 36 inches; late; pubescence gray; flowers both purple and white; pods medium large, 1½ to 2 inches long, tumid, half crowded, shattering moderately; seeds olive-yellow, medium-sized, 7½ to 8 mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown nine seasons. This variety was also obtained from Kobe, Japan, No. 20893.

17265. The progeny of 8423 from Yokohama, Japan, 1902. According to Ball this proved the same as the preceding and was united with it.

17266. The progeny of 4914 from Japan. According to Ball this also was the same as Tokyo 17264 and was finally united with it.

17267. *Hope.* The progeny of 6335 from Tokyo, Japan, 1901. Plants stout, erect, bushy; height 28 to 34 inches; late; pubescence gray; flowers both purple and white; pods medium large, 1¾ to 2¼ inches long, tumid, half crowded, shattering little; seeds olive-yellow, large, 8 to 8½ mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown nine seasons. No. 22881, also from Tokyo, is the same variety.

17268. *Ito San.* Plants stout, erect, bushy; height 18 to 22 inches; medium in maturity; pubescence tawny; flowers purple; pods medium-sized, 1½ to 1¾ inches long, tumid, half crowded, shattering moderately; seeds straw-yellow, medium-sized, 7½ to 8 mm. long, elliptical, slightly flattened; hilum pale, a brown speck at the micropylar end; germ yellow. Grown nine seasons.

This variety has also been known as "Japan Pea," "Coffee Berry," "Early Yellow," "Early White," and "Yellow Eda Mame." It is one of the earliest importations, very probably 1850, as the "Japan Pea." The Kansas Agricultural Experiment Station obtained this variety from Japan in 1890. Only one European importation has been made, this being from Vilmorin-Andrieux & Co., No. 21818, who advertise the variety as "Yellow Etampes." See also page 28.

17268 A. A field mass selection in 1907. Plants stout, erect, bushy; height 18 to 24 inches; medium late; pubescence tawny; flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, tumid, crowded, shattering little; seeds straw-yellow, medium-sized, 8 to 8½ mm. long, elliptical, slightly flattened; hilum brown; germ yellow. Grown two seasons.

17268 C. A field mass selection in 1907. Plants stout, erect, bushy; height 20 to 26 inches; medium; pubescence tawny; flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, compressed, half crowded, shattering little; seeds olive-yellow, medium-sized, 6½ to 7 mm. long, elliptical, much flattened; hilum seal-brown; germ yellow. Grown two seasons.

17269. *Medium Yellow.* The progeny of 6556 from central China, 1901. Plants stout, erect, bushy; height 30 to 36 inches; medium; pubescence tawny; flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, tumid, half crowded, shattering moderately; seeds straw-yellow, medium-sized, 7 to 7½ mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown nine seasons. This is the variety grown as Medium Yellow by the Tennessee Agricultural Experiment Station.

17269 D. A field mass selection in 1907. Plants stout, erect, bushy; height 24 to 30 inches; late; pubescence gray; flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, compressed, crowded, shattering little; seeds straw-yellow, medium-sized, 7 to 7½ mm. long, elliptical, slightly flattened; hilum light brown; germ yellow. Grown two seasons.

17270 The progeny of 4912 from Japan in 1900. Other numbers of the same progeny are 12399, 9407, and 5764. Plants stout, erect, bushy; height 24 to 30 inches; medium; pubescence tawny; flowers purple; pods medium-sized, 1¾ to 2 inches long, tumid, half crowded, shattering moderately; seeds straw-yellow, medium-sized, 7 to 7½ mm. long, elliptical, slightly flattened; hilum light to seal brown; germ yellow. Grown nine seasons.

17271. *Haberlandt.* The progeny of 6396 from Pingyang, Korea, 1901. Plants stout, erect, bushy; height 24 to 30 inches; medium late; pubescence tawny; flowers both purple and white; pods crowded, medium-sized, 1¾ to 2 inches long, tumid, shattering little; seeds straw-yellow, medium-sized, 8 to 8½ mm. long, elliptical, slightly flattened; hilum brown; germ yellow. Grown nine seasons.

17271 D. A pure field selection in 1907. Plants stout, erect, bushy; height 18 to 24 inches; medium late; pubescence tawny; flowers white; pods medium-sized, 1¾ to 2 inches long, tumid, half crowded, shattering little; seeds black, medium-sized, 8 to 8½ mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown two seasons.

17271 L. A pure field selection in 1908. Plants stout, erect, bushy; height 16 to 20 inches; medium early; pubescence tawny; flowers white; pods medium-sized, 1½ to 1¾ inches long, tumid, half crowded, shattering little; seeds chromium green, medium-sized, 7 to 7½ mm. long, elliptical, much flattened; hilum black; germ green. Grown one season.

17272. The progeny of 3870 from China in 1899. Plants slender, erect, the tips twining; height 32 to 36 inches; medium late; pubescence gray; flowers white; pods medium-sized, 1¾ to 2 inches long, tumid, half crowded, shattering little; seeds straw-yellow, medium-sized, 6½ to 7 mm. long, elliptical, much flattened; hilum brown; germ yellow. Grown ten seasons. Ball included this variety in Hollybrook, but it is different.

17273. *Butterball.* From the Rhode Island Agricultural Experiment Station, 1903, originally from Japan. Plants stout, erect, bushy; height 18 to 24 inches; medium; pubescence gray; flowers white; pods medium-sized, 1½ to 2 inches long, tumid, half crowded, shattering little; seeds straw-yellow, medium-sized, 7½ to 8 mm. long, elliptical, slightly flattened; hilum light brown; germ yellow. Grown seven seasons. This variety has also been obtained from the following foreign sources: Dammann & Co., Naples, Italy, No. 22415; Tokyo, Japan, Nos. 22878 and 22884; and Yokohama, Japan, No. 8422. See also page 30.

17274. The progeny of 8422 from Yokohama, Japan. Identical with 17273.

17275. *Amherst.* The united progenies of 4913 from Japan, 1900, and 6336 from Tokyo, Japan, 1901. Plants stout, erect, bushy; height 24 to 28 inches; medium late; pubescence tawny; flowers purple; pods medium-sized, 1 to 1½ inches long, tumid, crowded, shattering moderately; seeds straw-yellow, medium-sized, 7 to 7½ mm. long, elliptical, much flattened; hilum dark brown; germ yellow. Grown nine seasons.

17275 B. A field mass selection in 1907. Plants stout, erect, bushy; height, 14 to 18 inches; medium late; pubescence gray; flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, compressed, half crowded, shattering much; seeds olive-yellow, medium-sized, 8 to 8½ mm. long, elliptical, slightly flattened; hilum light brown; germ yellow. Grown two seasons.

17275 L. A field mass selection in 1908. Plants stout, erect, bushy; height, 14 to 18 inches; medium early; pubescence gray; flowers both purple and white; pods medium-sized, 1¾ to 2 inches long, tumid, crowded, shattering moderately; seeds straw-yellow, medium-sized, 7½ to 8 mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown one season.

17276. The progeny of Agrostology No. 1299 from Havre, France. Plants stout, erect, bushy; height, 14 to 18 inches; early; pubescence gray; flowers white; pods medium-sized, 1½ to 2 inches long, tumid, half crowded and shattering little; seeds straw-yellow, medium small, 7 to 7½ mm. long, elliptical, much flattened; hilum light to seal-brown; germ yellow. Grown eight seasons.

17277. *Manhattan.* The progeny of 6333 from Tokyo, Japan. Plants stout, erect, bushy; height, 14 to 18 inches; medium early; pubescence gray; flowers white; pods medium large, 1¾ to 2 inches long, tumid, crowded, shattering little; seeds straw-yellow, medium large, 8 to 8½ mm. long, elliptical, much flattened; hilum light brown; germ yellow. Grown ten seasons.

17277 A. A pure field selection in 1907. Plants stout, erect, bushy; height, 22 to 2[illegible] inches; medium late; pubescence tawny; flowers white; pods medium sized, 1¾ to 2 inches long, compressed, crowded, shattering little; seeds straw-yellow, medium large, 7½ to 8 mm. long, elliptical, slightly flattened; hilum seal-brown; germ yellow. Grown two seasons.

17277 C. A pure field selection in 1907. Plants stout, erect, bushy; height 16 to 2[illegible] inches; early; pubescence tawny; flowers purple; pods, large, 1¾ to [illegible] inches long, compressed, half crowded, shattering little; seeds raw umber, large, 8½ to 9 mm. long, elliptical, much flattened, hilum pale germ yellow. Grown two seasons.

17277 D. A pure field selection in 1907. Plants stout, erect, bushy; height 14 to 2[illegible] inches; medium; pubescence gray; flowers purple; pods medium-sized, 1½ to 2 inches long, tumid, half crowded, shattering little; seeds cinnamon brown, medium-sized, 8½ to 9 mm. long, elliptical, much flattened hilum pale; germ yellow. Grown two seasons.

17277 E. A pure field selection in 1907. Plants slender, erect, the tips vining; height 24 to 28 inches; medium; pubescence gray; flowers white; pods medium small, 1¼ to 1½ inches long, tumid, half crowded, shattering little; seeds straw-yellow, medium small, 6 to 6½ mm. long, elliptical, slightly flattened; hilum light brown; germ yellow. Grown two seasons.

17278. *Hollybrook.* From Arkansas Agricultural Experiment Station, 1904. Plants stout, erect, bushy; height 24 to 30 inches; late; pubescence gray; flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, tumid, crowded, shattering little; seeds straw-yellow, small to medium, 5½ to 6½ mm. long, elliptical, slightly flattened; hilum light brown; germ yellow. Grown six seasons. This variety was introduced by Messrs. T. W. Wood & Sons, of Richmond, Va., originally found mixed in Mammoth. Nos. 17269, 17270, 17272, and 17276 are all distinct.

17280. *Mammoth.* A combination of various lots; all from American sources. Plants stout, erect, bushy; height 36 to 42 inches; late; pubescence gray; flowers white; pods medium-sized, 1½ to 1¾ inches long, scattered, shattering little; seeds straw-yellow, medium small, 6½ to 7 mm. long, elliptical, slightly flattened; hilum brown; germ yellow. Grown ten seasons. This variety has also been grown under Nos. 4285, 25093, and 25162. It is the standard commercial late variety, more extensively grown at present than any other. See also page 29.

17520. *Hollybrook.* From Wood & Sons, Richmond, Va. Same as 17278.

17852. *Meyer.* From Peking, Chihli, China, 1906. Plants slender, erect, the tips twining; height 32 to 38 inches; late; pubescence tawny; flowers purple; pods large, 2 to 2¼ inches long, tumid, scattered, shattering little; seeds variable, black and brown, the colors usually in concentric bands, large, 8½ to 9 mm. long, elliptical, much flattened; hilum brown; germ yellow. Grown four seasons. The beans of this variety are said to be roasted and sold in Peking as delicatessen.

17852 B. *Peking.* A pure field selection in 1907. Plants slender, erect; height 32 to 36 inches; medium late; pubescence tawny; flowers white; pods small, 1¾ to 2 inches long, compressed, shattering little; seeds black, medium small, 7 to 7½ mm. long, oblong or nearly so, much flattened; hilum pale; germ yellow. Grown two seasons.

7852 C. A field mass selection in 1907. Plants slender, erect, the tips twining; height 24 to 30 inches; medium late; pubescence tawny; flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, compressed, half crowded, shattering moderately; seeds olive-brown, medium-sized, 8 to 8½ mm. long, oblong, much flattened; hilum pale; germ yellow. Grown two seasons.

7852 D. A pure field selection in 1907. Plants slender, suberect, the tips twining; stems 42 to 52 inches; medium late; pubescence tawny; flowers purple; pods medium-sized, 1¾ to 2 inches long, compressed, scattered, shattering little; seeds black, medium-sized, 7 to 7½ mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown two seasons.

7852 E. A field mass selection in 1907. Plants slender, erect; height 24 to 30 inches; medium late; pubescence gray; flowers both purple and white; pods small, 1¼ to 1¾ inches long, tumid, shattering little; seeds olive-yellow, medium small, 6½ to 7 mm. long, elliptical, much flattened; hilum light brown; germ yellow. Grown two seasons.

7852 N. A field mass selection in 1907. Plants stout, erect, bushy; height 18 to 30 inches; medium late; pubescence tawny; flowers purple; pods large, 2 to 2¼ inches long, compressed, half crowded, shattering much; seeds chromium green, large, 9½ to 10½ mm. long, broadly elliptical, much flattened; hilum slate-black; germ green. Grown two seasons. Except for color of seed this is identical with 17252, Flat King.

7852 R. A field mass selection in 1907. Plants slender, suberect, the tips twining; stems 48 to 56 inches; medium late; pubescence gray (10 per cent) and tawny (90 per cent); flowers both purple and white; pods small, 1¼ to 1½ inches long, compressed, scattered, shattering moderately; seeds medium-sized, 6½ to 7 mm. long, oblong, much flattened; hilum pale; germ yellow. Grown two seasons.

17857. From Shan-hai-kwan, Chihli, China, 1906. Plants slender, erect, the tips twining; height 28 to 32 inches; medium late; pubescence tawny; flowers both purple and white; pods medium large, 2 to 2¼ inches long, compressed, scattered, shattering little; seeds chromium green, medium-sized, 7 to 8 mm. long, elliptical, slightly flattened; hilum slate-black; germ green. Grown four seasons.

7857 B. A field mass selection in 1907. Plants slender, erect, the tips twining; height 30 to 36 inches; late; pubescence tawny; flowers both purple and white; pods medium-sized, 1¾ to 2¼ inches long, compressed, scattered, shattering moderately; seeds olive-yellow, medium small, 8 to 8½ mm. long, elliptical, much flattened; hilum black; germ yellow. Grown two seasons.

17861. *Jet.* From Sachon, Chihli, China, 1906. Plants slender, erect, the tips twining; height 36 to 48 inches; medium late; pubescence gray (40 per cent) and tawny (60 per cent); flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, compressed, scattered, shattering moderately; seeds black, medium small, 7 to 7½ mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown four seasons. A variety said to be grown for fodder and considered an excellent food for stock.

17862. *Sherwood.* From Tientsin, Chihli, China, 1906. Plants slender, erect, the tips twining; height 24 to 26 inches; medium late; pubescence gray; flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, tumid, half crowded, shattering little; seeds straw-yellow, medium-sized, 7 to 7½ mm. long, elliptical, slightly flattened; hilum pale or light brown; germ yellow. Grown four seasons. This variety is said to be excellent for making bean cheese. No. 22898 from Paotingfu, Chihli, China, is the same thing.

17862 B. A pure field selection in 1907. Plants stout, erect, bushy; height 32 to 36 inches; medium late; pubescence gray; flowers purple; pods medium-sized, 1½ to 2 inches long, compressed, scattered, shattering little; seeds chromium green, medium-sized, 7½ to 8 mm. long, oblong, much flattened; hilum black; germ green. Grown two seasons.

17862 C. A field mass selection in 1907. Plants slender, suberect, the tips twining; height 32 to 38 inches; medium late; pubescence tawny; flowers both purple and white; pods medium-sized, 2 to 2¼ incheslong, tumid, scattered, shattering moderately; seeds straw-yellow, medium small, 7¼ to 8 mm. long, elliptical, much flattened; hilum seal-brown; germ yellow. Grown two seasons.

17862 E. A field mass selection in 1907. Plants stout, erect, bushy; height 30 to 34 inches; medium late; pubescence gray; flowers both purple and white; pods medium-sized, 1½ to 1¾ inches, tumid, half crowded, shattering little; seeds olive-yellow, medium sized, 7 to 7½ mm. long, elliptical, much flattened; hilum pale to light brown; germ yellow. Grown two seasons.

17862 F. A field mass selection in 1907. Plants slender, erect, the tips twining; height 24 to 26 inches; medium late; pubescence gray; flowers both purple and white; pods medium-sized, 1¾ to 2 inches long, tumid, half crowded, shattering moderately; seeds straw-yellow, medium-sized, 7½ to 8 mm. long, elliptical, slightly flattened; hilum pale or brown; germ yellow. Grown two seasons.

17862 G. A pure field selection in 1907. Plants stout, erect, bushy; height 30 to 34 inches; medium late; pubescence tawny; flowers purple; pods medium sized, 1¾ to 2 inches long, tumid, half crowded, shattering little; seeds straw-yellow, medium-sized, 8 to 8½ mm. long, elliptical, much flattened; hilum pale to light brown; germ yellow. Grown two seasons.

18227. *Chernie.* From Khabarovsk, Siberia, 1906. Plants slender, erect, the tips twining; height 22 to 28 inches; medium early; pubescence tawny; flowers purple; pods medium-sized, 1½ to 1¾ inches long, compressed, half crowded, shattering little; seeds black, medium-sized, 7½ to 8½ mm. long, oblong, much flattened; hilum pale; germ yellow; leaves persist when pods are ripening. Grown four seasons.

18258. From Pee-san, Chihli, China, 1906. Plants slender, erect, the tips twining; height 28 to 34 inches; medium late; pubescence both gray and tawny; flowers both purple and white; pods medium-sized, 2 to 2¼ inches long, compressed, scattered, shattering little; seeds straw-yellow, medium sized, 7½ to 8 mm. long, oblong, much flattened; hilum brown; germ yellow. Grown four seasons.

18258 A. A field mass selection in 1907. Plants slender, erect, the tips twining; height 30 to 36 inches; medium late; pubescence both gray and tawny; flowers both purple and white; pods medium-sized, 1¾ to 2 inches long, compressed, scattered, shattering little; seeds straw-yellow, medium sized, 7½ to 8 mm. long, elliptical, much flattened; hilum seal-brown; germ yellow. Grown two seasons.

18258 D. A pure field selection in 1907. Plants slender, erect, the tips twining; height 30 to 34 inches; medium late; pubescence tawny; flowers white; pods medium-sized, 1¾ to 2 inches long, tumid, scattered, shattering little; seeds chromium green, medium-sized, 7½ to 8 mm. long, elliptical, slightly flattened; hilum black; germ green. Grown two seasons.

8258 E. A field mass selection in 1907. Plants stout, erect, bushy; height 26 to 30 inches; medium late; pubescence both gray and tawny; flowers white; pods medium-sized, 1¾ to 2 inches long, tumid, half crowded, shattering little; seeds chromium green, medium-sized, 7½ to 8 mm. long, elliptical, slightly flattened; hilum black; germ green. Grown two seasons.

8258 N. A pure field selection in 1908. Plants stout, erect, bushy; height 28 to 32 inches; medium late; pubescence tawny; flowers purple; pods medium-sized, 1½ to 1¾ inches long, compressed, half crowded, shattering little; seeds olive, with black saddle, medium-sized, 7 to 7½ mm. long, oblong, much flattened; hilum black; germ yellow. Grown two seasons.

18259. *Pingsu.* From Tschang-ping-tsu, Chihli, China, 1906. Plants slender, erect, the tips twining; height 32 to 36 inches; medium late; pubescence gray (50 per cent) and tawny (50 per cent); flowers both purple and white; pods medium-sized, 1¾ to 2 inches long, compressed, scattered, shattering much; seeds black, small, 8 to 8½ mm. long, oblong, much flattened; hilum pale; germ yellow. Grown four seasons. This bean is said to be grown in the northern country as a nitrogen-supplying crop with sorghum, corn, or millet.

18459. Guelph. From West Branch, Mich., 1906. Same as No. 17261.

18460. Buckshot. From West Branch, Mich., 1906. Same as No. 17251.

18619. From Shanghai, Kiangsu, China, 1906. Plants stout, erect, bushy; height 24 to 30 inches; very late; pubescence tawny; flowers purple, pods medium-sized, 2 to 2¼ inches long, compressed, scattered, shattering little; seeds straw-yellow, medium-sized, 7 to 7½ mm. long, elliptical, much flattened; hilum dark brown; germ yellow. Grown four seasons. This variety is said to be used in Shanghai as a vegetable after the beans have made sprouts several inches long.

19183. *Wilson.* From Newchwang, Manchuria, 1906. Plants slender, erect, the tips twining; height 36 to 48 inches; medium late; pubescence gray (10 per cent) and tawny (90 per cent); flowers both purple and white; pods medium-sized, 1¾ to 2 inches long, compressed, scattered, shattering little; seeds black, medium, 7½ to 8 mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown three seasons. This variety has an admixture of medium-sized, subglobose, black seed with green cotyledons. This variety is said to be grown for oil, the exhausted material being exported as a very valuable fertilizer.

9183 B. A field mass selection in 1907. Plants slender, erect, the tips twining; height 36 to 48 inches; medium late; pubescence gray; flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, compressed, scattered, shattering little; seeds olive-yellow, medium small, 7 to 7½ mm. long, elliptical, much flattened; hilum light brown to russet; germ yellow. Grown two seasons.

19184. *Fairchild.* From Newchwang, Manchuria, 1906. Plants stout, erect, bushy; height, 30 to 34 inches; medium; pubescence tawny; flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, tumid, half crowded, shattering little; seeds black, medium-sized, 7 to 7½ mm. long, elliptical, slightly flattened; hilum pale; germ green. Grown three seasons. This is said to be a very rare variety used both for food and for making a superior oil.

9184 A. A pure field selection in 1907. Plants stout, erect, bushy; height 34 to 38 inches; medium late; pubescence gray; flowers white; pods medium-sized, small, 1¼ to 1¾ inches long, tumid, half crowded, shattering little; seeds straw-yellow, medium-sized, 7 to 7½ mm. long, elliptical, slightly flattened; hilum brown; germ yellow. Grown two seasons.

19184 C. A field mass selection in 1907. Plants slender, erect, the tips twining; height 36 to 48 inches; medium late; pubescence tawny; flowers both purple and white; pods medium-sized, 1½ to 2 inches long, tumid, scattered, shattering little; seeds olive-yellow, medium-sized, 7 to 7 mm. long, elliptical, slightly flattened; hilum black; germ yellow. Grown two seasons.

19184 D A field mass selection in 1907. Plants stout, erect, bushy; height 20 to 2 inches; medium late; pubescence tawny; flowers both purple and white; pods large, 2 to 2½ inches long, tumid, half crowded, shattering little; seeds olive-yellow, large, 7 to 7½ mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown two seasons.

19184 E. A pure field selection in 1907. Plants stout, erect, bushy; height 22 to 2 inches; medium late; pubescence gray; flowers white; pods medium sized, 1¾ to 2¼ inches long, tumid, half crowded, shattering little; seeds olive-yellow, medium large, 7½ to 8 mm. long, oval; hilum brown; germ yellow. Grown three seasons.

19184 G. A pure field selection in 1907. Plants stout, erect, bushy; height 18 to 2 inches; medium late; pubescence tawny; flowers purple; pods medium sized, 1½ to 2 inches long, tumid, crowded, shattering moderately; seeds straw-yellow, medium-sized, 7½ to 8 mm. long, elliptical, much flattened; hilum black; germ yellow. Grown two seasons.

19186. *Morse.* From Newchwang, Manchuria, 1906. Plants stout, erect, bushy; height 30 to 36 inches; medium late; pubescence gray; flowers both purple and white; pods medium large, 1¾ to 2¼ inches long, tumid, half crowded, shattering moderately; seeds olive-yellow, medium large, 7½ to 8 mm. long, elliptical, slightly flattened; hilum brown; germ yellow. Grown three seasons. This variety is said to be the most common one from which oil is extracted at Newchwang.

19186 B. A pure field selection in 1907. Plants slender, suberect, the tips twining; stems 48 to 60 inches; medium late; pubescence gray; flowers purple; pods medium-sized, 1¾ to 2 inches long, compressed, scattered, shattering little; seeds black, medium-sized, 7½ to 8 mm. long, oblong, much flattened; hilum pale; germ yellow. Grown two seasons.

19186 C. A field mass selection in 1907. Plants stout, erect, bushy; height 20 to 24 inches; medium late; pubescence gray; flowers both purple and white; pods large, 2 to 2½ inches long, tumid, half crowded, shattering little; seeds cinnamon brown, medium large, 7½ to 8 mm. long, elliptical, slightly flattened, breaking easily; hilum pale; germ yellow. Grown two seasons.

19186 D. A pure field selection in 1907. Plants slender, suberect, the tips twining; stems 48 to 56 inches long; medium late; pubescence tawny; flowers purple; pods medium-sized, 1¾ to 2 inches long, compressed, scattered, shattering little; seeds brown, medium-sized, 8½ to 9 mm. long, oblong, much flattened; hilum pale; germ yellow. Grown two seasons.

19186 F. A field mass selection in 1907. Plants slender, suberect, the tips twining; height 36 to 42 inches; medium late; pubescence tawny; flowers both purple and white; pods medium-sized, 1¾ to 2 inches long, tumid, scattered, shattering little; seeds straw-yellow, medium-sized, 7½ to 8 mm. long, elliptical, much flattened; hilum dark brown; germ yellow. Grown two seasons.

19951. *Mammoth.* From Richmond, Va.

19981. From Yokohama, Japan, 1907. Plants stout, erect, bushy; height 18 to 22 inches; medium; pubescence gray; flowers both purple and white; pods large, 2¼ to 2½ inches long, tumid, crowded, shattering moderately; seeds straw-yellow, large, 9½ to 10 mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown three seasons. No. 19983 from Yokohama is the same, and the variety has also been obtained from Tokyo, Japan, Nos. 22882 and 22885.

19981 A. A field mass selection in 1907. Plants stout, erect, bushy; height 22 to 26 inches; late; pubescence gray; flowers both purple and white; pods large, 2¼ to 2½ inches long, compressed, crowded, shattering little; seeds straw-yellow, large, 8½ to 9 mm. long, elliptical, slightly flattened; hilum light brown; germ yellow. Grown two seasons.

19981 B. A pure field selection in 1907. Plants stout, erect, bushy; height 20 to 24 inches; medium; pubescence tawny; flowers purple; pods large, 2 to 2¼ inches long, tumid, crowded, shattering little; seeds olive-yellow, large, 7½ to 8 mm. long, oval; hilum black; germ yellow. Grown two seasons.

19982. From Yokohama, Japan, 1907. This is identical with Flat King, 17252.

19983. From Yokohama, Japan, 1907. This is the same variety as 19981.

19984. *Natsu.* From Yokohama, Japan, 1907. Plants stout, erect, bushy; height 18 to 30 inches; late; pubescence gray (25 per cent) and tawny (75 per cent); flowers both purple and white; pods medium large, 2 to 2¼ inches long, tumid, half crowded, shattering little; seeds straw-yellow, medium-sized, 8 to 8½ mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown three seasons.

19984 A. A pure field selection in 1907. Plants stout, erect, bushy; height 30 to 42 inches; medium late; pubescence tawny; flowers purple; pods medium small, 1¼ to 1½ inches long, compressed, scattered, shattering little; seeds brownish olive, medium-sized, 6 to 6½ mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown two seasons.

19984 B. A pure field selection in 1907. Plants stout, erect, bushy; height 24 to 30 inches; late; pubescence gray; flowers white; pods medium large, 2 to 2¼ inches long, tumid, half crowded, shattering little; seeds buff, medium large, 7½ to 8 mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown two seasons.

19984 D. A field mass selection in 1907. Plants stout, erect, bushy; height 36 to 42 inches; late; pubescence tawny; flowers both purple and white; pods medium large, 2 to 2¼ inches long, compressed, scattered, shattering little; seeds olive-yellow, medium-sized, 8½ to 9 mm. long, elliptical, much flattened; hilum clove-brown; germ yellow. Grown two seasons.

19985. *Nemo.* From Yokohama, Japan, 1907. Plants stout, erect, bushy; height 28 to 32 inches; medium late; pubescence tawny; flowers white; pods medium-sized 1¾ to 2 inches long, tumid, half crowded, shattering little; seeds olive-yellow, medium-sized, 7 to 7½ mm. long, elliptical, slightly flattened; hilum light to slate-black; germ yellow. Grown three seasons.

19985 F. A field mass selection in 1907. Plants stout, bushy; height 32 to 38 inches; medium late; pubescence tawny; flowers both purple and white; pods medium-sized, 1¾ to 2 inches long, tumid, scattered, shattering little; seeds olive-yellow, medium-sized, 6½ to 7 mm. long, elliptical, slightly flattened; hilum black; germ yellow. Grown three seasons.

19985 K. A field mass selection in 1908. Plants stout, erect, bushy; height 24 to 30 inches; medium late; pubescence tawny; flowers both purple and white; pods medium-sized, 1½ to 2 inches, tumid, half crowded, shattering little; seeds olive-yellow, medium-sized, 7 to 7½ mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown one season.

19986. *Okute*. From Yokohama, Japan, 1907. Plants stout, erect, bushy; height 14 to 18 inches; early; pubescence tawny; flowers both purple and white; pods large, 2 to 2½ inches long, tumid, half crowded, shattering little; seeds olive-yellow, large, 9½ to 10 mm. long, elliptical, much flattened; hilum slate-colored; germ yellow. Grown three seasons. This variety was also received from Tokyo, Japan, No. 22877.

19987. From Yokohama, Japan. Very similar to, if not identical with Buckshot, 17251.

20011. From Ko-bau, northern Korea, 1906. Plants stout, erect, bushy; height 15 to 18 inches; medium; pubescence tawny; flowers purple; pods medium-sized, 1½ to 1¾ inches long, compressed, half crowded, shattering little; seeds olive-yellow, small to medium, 6½ to 7 mm. long, elliptical, much flattened; hilum seal-brown; germ yellow; leaves persisting when pods are ripening. Grown three seasons. This variety is said to be grown at high elevation in Korea.

20011 A. A pure field selection in 1907. Plants stout, erect, bushy; height 20 to 24 inches; medium; pubescence tawny; flowers purple; pods medium-sized, 1½ to 1¾ inches long, compressed, scattered, shattering little; seeds straw-yellow, small, 6½ to 7 mm. long, elliptical, much flattened; hilum brown; germ yellow. Grown two seasons.

20405. *Habaro*. From Khabarovsk, Siberia, 1906. Plants stout, erect, bushy; height 18 to 24 inches; medium; pubescence both gray and tawny; flowers purple; pods medium-sized, 1½ to 1¾ inches long, tumid, half crowded, shattering little; seeds straw-yellow, medium-sized, 7½ to 8 mm. long, elliptical, slightly flattened; hilum light brown; germ yellow. Grown three seasons.

20405 B. *Chestnut*. A field mass selection in 1907. Plants stout, erect, bushy; height 24 to 30 inches; medium early; pubescence gray (25 per cent) and tawny (75 per cent); flowers purple; pods medium-sized, 1½ to 1¾ inches long, tumid, half crowded, shattering little; seeds brown, medium large, 7 to 7½ mm. long, oblong, much flattened; hilum pale; germ yellow, leaves persist when pods are ripening. Grown two seasons.

20405 C. A pure field selection in 1907. Plants stout, erect, bushy; height 20 to 26 inches; medium; pubescence tawny; flowers purple; pods medium-sized, 1½ to 1¾ inches long, tumid, half crowded, shattering moderately; seeds olive-yellow, medium-sized, 7½ to 8 mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown two seasons.

20406. *Elton*. From Khabarovsk, Siberia, 1906. Plants stout, erect, bushy; height 28 to 32 inches; medium early; pubescence both gray and tawny; flowers purple; pods medium large, 1¾ to 2 inches long, compressed, half crowded, shattering little; seeds straw-yellow, medium large, 7½ to 8 mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown three seasons.

20406 C. A pure field selection in 1907. Plants stout, erect, bushy; height 18 to 22 inches; medium; pubescence tawny; flowers purple; pods medium-sized, 1¾ to 2 inches long, tumid, scattered, shattering little; seeds straw-yellow with brown saddle, medium-sized, 8 to 9 mm. long, elliptical, much flattened; hilum brown; germ yellow; leaves persisting while pods are ripening. Grown two seasons.

20406 E. A pure field selection in 1907. Plants stout, erect, bushy; height 12 to 16 inches; medium; pubescence tawny; flowers purple; pods medium-sized, 1½ to 2 inches long, tumid, crowded, shattering moderately; seeds olive-yellow, medium-sized, 8 to 9 mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown two seasons.

20406 G. A pure field selection in 1907. Plants stout, erect, bushy; height 24 to 28 inches; medium early; pubescence gray; flowers purple; pods large, 2 to $2\frac{1}{4}$ inches long, compressed, half crowded, shattering little; seeds light brown, large, $8\frac{1}{2}$ to 9 mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown two seasons.

20407. *Brindle.* From Merkoechofka, Siberia, 1906. Plants stout, erect, bushy; height 16 to 20 inches; medium; pubescence tawny; flowers purple; pods large, $1\frac{3}{4}$ to $2\frac{1}{4}$ inches long, tumid, half crowded, shattering little; seeds brown and black, the colors somewhat concentrated in bands, large, 8 to 9 mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown three seasons. This variety is said to be used in Siberia for human food, being boiled with millet.

20407 B. A field mass selection in 1907. Plants stout, erect, bushy; height 18 to 24 inches; medium; pubescence tawny; flowers both purple and white; pods medium-sized, $1\frac{1}{2}$ to $1\frac{3}{4}$ mm. long, tumid, half crowded, shattering little; seeds straw-yellow, medium-sized, $8\frac{1}{2}$ to 9 mm. long, elliptical, much flattened; hilum brown; germ yellow. Grown two seasons.

20408. From Khabarovsk, Siberia, 1906. Seeds black. They failed to germinate in 1907.

20409. *Hansen.* From Merkoechofka, Siberia, 1906. Plants slender, erect, the tips twining; height 16 to 20 inches; early; pubescence tawny; flowers purple; pods small, $1\frac{1}{4}$ to $1\frac{1}{2}$ mm. long, tumid, crowded, shattering little; seeds brown, very small, 5 to $5\frac{1}{2}$ mm. long, oblong, much flattened; hilum pale; germ yellow. Grown three seasons.

20410. From Merkoechofka, Siberia, 1906. Plants stout, erect, bushy; height 12 to 15 inches; medium early; pubescence tawny; flowers purple; pods small, $1\frac{1}{4}$ to $1\frac{1}{2}$ inches long, compressed, half crowded, shattering much; seeds black, small, 6 to $6\frac{1}{2}$ mm. long, elliptical, much flattened; hilum pale; germ yellow; leaves persist when pods are ripening. Grown three seasons.

20411. From Merkoechofka, Siberia, 1906. Plants stout, erect, bushy; height 16 to 20 inches; medium early; pubescence tawny, flowers both purple and white; pods small, $1\frac{1}{4}$ to $1\frac{1}{2}$ inches long, tumid, crowded, shattering moderately; seeds dull black marbled with brown, small, 5 to $5\frac{1}{2}$ mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown three seasons.

20412. *Merko.* From Merkoechofka, Siberia, 1906. Plants slender, erect, the tips twining; height 28 to 32 inches; medium early; pubescence gray (60 per cent) and tawny (40 per cent); flowers both purple and white; pods medium small, $1\frac{1}{2}$ to $1\frac{3}{4}$ inches long, compressed, scattered, shattering little; seeds brown, small, $7\frac{1}{2}$ to 8 mm. long, oblong, much flattened, hilum pale; germ yellow; leaves persist when pods are ripening. Grown three seasons.

20412 A. A pure field selection in 1907. Plants stout, erect, bushy; height 16 to 18 inches; medium; pubescence tawny; flowers purple; pods medium-sized, $1\frac{3}{4}$ to 2 inches long, compressed, half crowded, shattering little; seeds deep brown, medium small, $7\frac{1}{2}$ to 8 mm. long, elliptical, much flattened; hilum pale; germ yellow; leaves persist when pods are ripening. Grown two seasons.

20412 B. A pure field selection in 1907. Plants stout, erect, bushy; height 20 to 24 inches; medium; pubescence tawny; flowers purple; pods medium-sized, $1\frac{1}{2}$ to $1\frac{3}{4}$ inches long, tumid, half crowded, shattering moderately; seeds olive to mummy brown, medium large, $7\frac{1}{2}$ to 8 mm. long, elliptical, much flattened; hilum pale; germ yellow; leaves persist when pods are ripening. Grown two seasons.

20414. From Merkoechofka, Siberia, 1906. Identical with Chernie, 18227.

20629. From Manchuria, March, 1907. Seeds failed to germinate.

20699. From Usuri Province, Siberia, March, 1907. Seeds failed to germinate.

20797. *Riceland.* From Chinhuafu, near Shanghai, Kiangsu, China, 1907. Plants slender, erect, very leafy; height 36 to 42 inches; very late; pubescence tawny; flowers purple; pods medium small, 1½ to 1¾ inches long, compressed, scattered, shattering little; seeds black, medium small, 6½ to 7 mm. long, oblong; much flattened; hilum pale; germ yellow. Grown three seasons. No. 23337 from Shanghai is the same thing. This variety is said to be grown as a second crop in low-lying rice fields and mainly used as a fodder for domestic animals. It is not quite identical with the original Riceland, No. 6560.

20798. *Barchet.* From Chinhuafu, Kiangsu, China, 1907. Plants slender, erect, very leafy; height 36 to 42 inches; late; pubescence tawny; flowers purple; pods medium small, 1½ to 1¾ inches long, compressed, scattered, shattering little; seeds dark olive-brown, medium-sized, 6½ to 7 mm. long, oblong, much flattened; hilum pale; germ yellow. Grown three seasons. This variety has also been grown under No. 23336 from Shanghai, China, and 9344 is almost certainly the same thing.

20798 C. A selection out of the original seed of 20798. Plants stout, erect, bushy; height 30 to 36 inches; very late; pubescence tawny; flowers purple; pods medium-sized, 1¾ to 2 inches long, compressed, scattered, shattering little; seeds olive-yellow, medium-sized, 7½ to 8 mm. long, elliptical, much flattened; hilum burnt umber; germ yellow; leaves persist while pods are ripening. Grown two seasons.

20798 E. A selection out of the original seed of 20798. Plants slender, erect, the tips twining; height 36 to 42 inches; very late; pubescence tawny; flowers purple; pods medium-sized, 1¼ to 1½ inches long, compressed, scattered, shattering little; seeds olive-yellow, 6½ to 7 mm. long, elliptical, much flattened; hilum dark brown; germ yellow. Grown two seasons.

20854. *Tashing.* From Harbin, Manchuria, 1907. Plants stout, erect, bushy; height 14 to 18 inches; medium; pubescence tawny; flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, tumid, half crowded, shattering little; seeds chromium green, medium-sized, 7½ to 8 mm. long, elliptical, slightly flattened; hilum black; germ green. Grown three seasons.

20892. From Kobe, Japan, 1907. Plants stout, erect, bushy; height 24 to 30 inches; late; pubescence gray (5 per cent) and tawny (95 per cent), flowers both purple and white; pods large, 2 to 2½ inches long, tumid, half crowded, shattering moderately; seeds straw-yellow, large, 8½ to 9 mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown three seasons.

20892 A. A pure field selection in 1908. Plants stout, erect, bushy; height 12 to 18 inches; medium early; pubescence gray; flowers purple; pods medium-sized, 1¾ to 2 inches long, tumid, half crowded, shattering moderately; seeds straw-yellow, medium-sized, 8½ to 9 mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown two seasons.

20893. From Kobe, Japan, 1907. This proved to be identical with Tokyo, 17264.

20893 A. A pure field selection in 1908. Plants stout, erect, bushy; height 24 to 30 inches; late; pubescence tawny; flowers purple; pods large, 2 to 2¼ inches long, tumid, crowded, shattering moderately; seeds straw-yellow, very large, 9 to 9½ mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown two seasons.

21079. *Shingto.* From Tieling, Manchuria, 1907. Plants stout, erect, bushy; height 24 to 30 inches; medium; pubescence tawny; flowers white; pods medium-sized, 1½ to 1¾ inches long, tumid, scattered, shattering little; seeds olive-yellow, medium-sized, 6½ to 7 mm. long, elliptical, slightly flattened; hilum light to slate-black; germ yellow. Grown three seasons. This variety is said to be used to produce bean oil and bean cake.

21079 A. *Auburn.* A field mass selection in 1907. Plants stout, erect, bushy; height 24 to 28 inches; medium early; pubescence gray (30 per cent) and tawny (70 per cent); flowers white; pods medium-sized, 1¾ to 2 inches long, compressed, half crowded, shattering little; seeds black, medium-sized, 7½ to 8 mm. long, elliptical, much flattened; hilum pale; germ green. Grown two seasons.

21079 D. A field mass selection in 1907. Plants stout, erect, bushy; height 20 to 24 inches; medium; pubescence tawny; flowers both purple and white; pods medium sized, 1½ to 1¾ inches long, tumid, half crowded, shattering little; seeds olive-yellow, medium-sized, 7 to 7½ mm. long, elliptical, slightly flattened; hilum dark brown; germ yellow. Grown two seasons.

21079 H. A pure field selection in 1907. Plants stout, erect, bushy, height 24 to 30 inches; medium; pubescence tawny; flowers purple; pods medium-sized, 1¾ to 2 inches long, compressed; crowded, shattering moderately; seeds straw-yellow, medium-sized, 7½ to 8 mm. long, elliptical, much flattened; hilum brown; germ yellow. Grown two seasons.

21080. From Tieling, Manchuria, 1907. Plants stout, erect, bushy; height 14 to 18 inches; medium; pubescence tawny; flowers white; pods medium-sized, 1¾ to 2 inches long, tumid, half crowded, shattering little; seeds chromium green, medium-sized, 9 to 9½ mm. long, elliptical, slightly flattened; hilum brown; germ green. Grown three seasons. This variety is said to be the most expensive of all the soy beans at Tieling and is eaten only by the better classes of Chinese.

21080 K. A field selection in 1908. Plants stout, erect, bushy; height 22 to 26 inches; medium early; pubescence tawny; flowers purple; pods medium-sized, 1½ to 1¾ inches long, tumid, half crowded, shattering little; seeds smoky yellow, medium-sized, 7 to 7½ mm. long, elliptical, slightly flattened; hilum brown; germ yellow. Grown one season.

21080 L. A field selection in 1908. Plants stout, erect, bushy; height 12 to 16 inches; medium early; pubescence tawny; flowers white; pods large, 1½ to 1¾ inches long; tumid, crowded, shattering a little; seeds dark brown, large, 10 to 10½ mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown one season.

21080 N. A field selection in 1908. Plants stout, erect, bushy; height 12 to 16 inches; medium early; pubescence tawny; flowers both purple and white; pods medium large, 1½ to 1¾ inches long, tumid, crowded, shattering little; seeds chromium green, large, 8½ to 9 mm. long, elliptical, slightly flattened; hilum pale; germ green. Grown one season.

21731. *Mammoth.* From Hickory, N. C.

21754. From Vilmorin-Andrieux & Co., Paris, France, 1908. Plants stout, bushy, erect; height 10 to 14 inches; medium; pubescence tawny; flowers purple; pods medium sized, 1¾ to 2 inches long, tumid, crowded, shattering little; seeds straw-yellow, medium small, 7½ to 8 mm. long, elliptical, much flattened; hilum seal-brown; germ yellow. Grown two seasons, This variety was also obtained from Dammann & Co., Naples, Italy, and grown under S. P. I. No. 22414.

21755. From Vilmorin-Andrieux & Co., Paris, France, 1908. Plants stout, bushy, erect; height 12 to 16 inches; very early; pubescence tawny; flowers white; pods large, 2 to 2¼ inches long, tumid, half crowded, shattering moderately; seeds deep brown, medium large to large, 8 to 9 mm. long, elliptical, much flattened; hilum pale; germ yellow. Except for length of season, this could not be distinguished from 17258, Ogemaw. Grown two seasons.

21756. From Vilmorin-Andrieux & Co., Paris, France, 1908. This is identical with 18227.

21757. Identical with the preceding and from the same source.

21818. From Vilmorin-Andrieux & Co., Paris, France, 1908. This could not be distinguished from Ito San, 17268.

21825. From Hokkaido, Japan, 1908. Plants stout, erect, bushy; height, 16 to 20 inches, medium early; pubescence tawny; flowers purple; pods medium-sized; 1½ to 1¾ inches long, tumid, half crowded, shattering moderately; seeds straw-yellow, medium-sized, 8 to 8½ mm. long, elliptical, slightly flattened; hilum brown; germ yellow. Grown two seasons. This variety is said to be used principally in the manufacture of "soy," "miso," "tifu," etc. It has also been obtained again from the same place and grown under Nos. 21830 and 21831.

21830. From Hokkaido, Japan, 1908.

21831. From Hokkaido, Japan, 1908.

Both these numbers produced plants that were identical with 21825.

21946. From Buitenzorg, Java, 1908. A black-seeded variety, but the seeds failed to germinate.

21999. *Taha.* From Boshan, Shangtung, China, 1907. Plants slender, erect, the tips twining; height, 28 to 32 inches; medium late; pubescence gray (5 per cent) and tawny (95 per cent); flowers both purple and white; pods large, 2 to 2¼ inches long, compressed, scattered, shattering little; seeds black with olive saddle, large, 9 to 10 mm. long, elliptical, much flattened; hilum black; germ yellow. Grown two seasons. This is said to be a rare variety of soy bean, used by the higher classes of Chinese as a vegetable in soups.

21999 B. A mass selection out of the original seed. Plants slender, erect, the tips twining; height, 36 to 48 inches; late; pubescence tawny; flowers white; pods large, 2 to 2¼ inches long, compressed, scattered, shattering little; seeds brown, large, 8 to 9 mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown two seasons.

21999 C. A mass selection out of the original seed. Plants slender, erect, the tips twining; height, 42 to 48 inches; late; pubescence gray (40 per cent) and tawny (60 per cent); flowers both purple and white; pods scattered, shattering little, medium-sized, 1½ to 2 inches long, compressed; seeds olive-yellow, medium-sized, 7 to 7½ mm. long, elliptical, much flattened; hilum slate-black; germ yellow. Grown two seasons.

21999 D. A mass selection out of the original seed. Plants slender, erect, the tips twining; height, 30 to 42 inches; late; pubescence tawny; flowers both purple and white; pods large, 2¼ to 2½ inches long, tumid, half crowded, shattering little; seeds olive-yellow, large, 8½ to 9 mm. long, elliptical, slightly flattened; hilum black; germ yellow. Grown two seasons.

22311. From Shanghai, China, 1908. This proved to be the same as 14952 from the same place.

22312. *Farnham.* From Shanghai, China, 1908. Plants stout, erect, bushy; height 36 to 40 inches; late; pubescence gray; flowers purple; pods medium-sized, 1½ to 1¾ inches long, tumid, scattered, shattering moderately; seeds straw-yellow, medium-sized, 7 to 7½ mm. long, elliptical, slightly flattened; hilum brown; germ yellow. Grown two seasons.

22317. From Haage & Schmidt, Erfurt, Germany, 1908. A yellow-seeded sort, but the seed did not germinate.

22318. From Erfurt, Germany, 1908. Plants stout, erect, bushy; height, 24 to 32 inches; very late; pubescence gray; flowers white; pods medium-sized, 1½ to 1¾ inches long, tumid, scattered, shattering little; seeds straw-yellow, medium-sized; 8 to 8½ mm. long, elliptical, slightly flattened; hilum light brown; germ yellow. Grown two seasons.

22318 A. A field selection in 1908. Plants stout, erect, bushy; height 36 to 40 inches; late; pubescence gray; flowers white; pods medium-sized, 1½ to 1¾ inches long, compressed, scattered, shattering little; seeds straw-yellow, medium small, 5½ to 6 mm. long, elliptical, slightly flattened; hilum brown; germ yellow. Grown one season.

22319. From Haage & Schmidt, Erfurt, Germany, 1908. A brown-seeded variety, but the seed did not germinate.

22320. From Haage & Schmidt, Erfurt, Germany, 1908, as "Green from Samarow." Identical with Guelph, 17261.

22321. From Haage & Schmidt, Erfurt, Germany. Identical with Chernie, 18227.

22322. From Haage & Schmidt, Erfurt, Germany, 1908, as "Early Black from Podolia." The same thing as Buckshot, 17251.

22333. *Baird.* The progeny of 17256 A. Selected out of 17256, grown from 6414 from Pingyang, Korea, 1901. Plants stout, erect, bushy; height 30 to 36 inches; late; pubescence gray; flowers both purple and white; pods medium small, 1¼ to 1½ inches long, tumid, half crowded, shattering little; seeds brown, medium small, 5½ to 6 mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown nine seasons.

22334. From the Illinois Agricultural Experiment Station, 1908. Identical with Nuttall, 17253, and, as the records show, grown from seed obtained from the Department of Agriculture.

22335. From the Illinois Agricultural Experiment Station, 1908. Plants stout, erect, bushy; height 16 to 20 inches; medium; pubescence gray and tawny; flowers white; pods medium-sized, 1¼ to 1¾ inches long, tumid, half crowded, shattering moderately; seeds straw-yellow, medium-sized, 6½ to 7 mm. long, oval; hilum pale; germ yellow. Grown two seasons.

22336. From the Illinois Agricultural Experiment Station, 1908. Both this and 22337 proved to be identical with Guelph, 17261.

22336 A. A pure field selection in 1908. Plants stout, erect, bushy; height 12 to 15 inches; medium early; pubescence tawny; flowers purple; pods medium-sized, 1½ to 2 inches long, tumid, half crowded, shattering moderately; seeds black, medium-sized, 8 to 8½ mm. long, elliptical, much flattened; hilum pale; germ green. Grown one season.

22337. See 22336.

22379. *Swan.* From Canton, Kwangtung, China, 1908. Plants stout, erect, bushy; height 26 to 30 inches; medium; pubescence gray; flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, tumid, half crowded, shattering moderately; seeds straw-yellow, medium-sized, 6½ to 7 mm. long, elliptical, slightly flattened; hilum light brown; germ yellow. Grown two seasons.

22380. From Canton, Kwangtung, China, 1908. Plants slender, erect, the tips twining; height 30 to 36 inches; late; pubescence tawny; flowers white; pods large, 2 to 2½ inches long, compressed, scattered, shattering moderately; seeds black, large, 7½ to 8½ mm. long, elliptical, slightly flattened; hilum pale; germ green. Grown two seasons.

22381. From Canton, Kwangtung, China, 1908. Plants stout, erect, bushy; height 18 to 24 inches; late; pubescence gray (25 per cent) and tawny (75 per cent); flowers both purple and white; pods medium large, 2 to 2½ inches long, tumid, crowded, shattering moderately; seeds olive-yellow, medium-sized; 7½ to 8 mm. long, oval; hilum pale; germ yellow. Grown two seasons.

22381 B. A pure selection in 1908. Plants stout, erect, bushy; height 12 to 16 inches; medium early; pubescence tawny; flowers white; pods large, 2 to 2½ inches long, tumid, half crowded, shattering little; seeds olive-yellow (smoky), large, 9½ to 10 mm. long, elliptical, slightly flattened; hilum pale; germ green. Grown one season.

22406. *Hongkong*. From Hongkong, Kwangtung, China, 1908. Plants stout, erect, bushy; height 24 to 30 inches; medium late; pubescence tawny; flowers both purple and white; pods scattered, shattering little, 1¾ to 2 inches long, tumid; seeds black, medium-sized, 7½ to 8 mm. long, oblong, slightly flattened; hilum pale; germ green. Grown two seasons.

22407. *Nigra*. From Hongkong, China, 1908. Plants slender, erect, the tips twining; height 24 to 30 inches; medium; pubescence gray (8 per cent) and tawny (20 per cent); flowers both purple and white; pods medium-sized, 1¾ to 2 inches long, tumid, scattered, shattering moderately; seeds black, medium-sized, 8½ to 9 mm. long, oblong, much flattened; hilum pale; germ green. Grown two seasons.

22411. From Dammann & Co., Naples, Italy, 1908, as "Samarow." This proved to be identical with 17260.

22411 A. A pure field selection in 1907. Plants stout, erect, bushy; height 12 to 16 inches; medium early; pubescence tawny; flowers purple; pods small, 1¼ to 1½ inches long, compressed, crowded, shattering much; seeds dull brown, very small, 5 to 5½ mm. long, oblong, much flattened; hilum pale; germ yellow. Grown two seasons.

22412. From Dammann & Co., Naples, Italy, 1908. The plants were exactly like Chernie, 18227.

22413. From Dammann & Co., Naples, Italy. Seeds brown, but none germinated.

22414. From Dammann & Co., Naples, Italy, 1908. This is exactly the same variety as 21754.

22415. From Dammann & Co., Naples, Italy, as "Giant Yellow." The plants and seeds of this can not be distinguished from Butterball, 17273.

22428. Wild soy bean from the botanic gardens, Tokyo, Japan, 1908. Plants very slender, very vining, procumbent; length of stems 36 to 48 inches; very late; pubescence tawny; flowers purple; pods small, ¾ to 1¼ inches long, compressed, scattered, shattering very much; seeds dull black, oblong, much flattened, very small, 3½ to 4 mm. long; hilum pale; germ yellow. Grown three seasons. (See Pl. I.) No. 25138, from Soochow, Kiangsu, China, is identical. (See Pl. II, fig. 1.) This is the wild form of the soy bean. It volunteers very readily at Arlington Experimental Farm, the seedlings appearing about May 1. Were it not that the seed shatters so badly, the plant would have promise as a cover crop.

22498. From Hangchow, Chekiang, China, 1908. Plants stout, erect, bushy; height 16 to 20 inches; very late; pubescence tawny; flowers purple; pods scattered, never fully maturing at Arlington Experimental Farm; seeds straw-yellow, medium-sized, 7½ to 8 mm. long, elliptical, slightly flattened; hilum dark brown; germ yellow. Grown two seasons.

22499. From Hangchow, Chekiang, China. Seeds straw-yellow, but none germinated.

22500. From Hangchow, Chekiang, China, 1908. Plants stout, erect, bushy; height 24 to 28 inches; very late; pubescence tawny; flowers white; pods half crowded; seeds chromium green, medium-sized, 9 to 10 mm. long, elliptical, slightly flattened; hilum brown; germ green. Grown two seasons.

22501. From Hangchow, China, 1908. Plants slender, erect, the tips twining; height 42 to 48 inches; very late; pubescence tawny; flowers white; pods medium large, 2 to 2¼ inches long, compressed, scattered, shattering little; seeds black, medium large, 7 to 7½ mm. long, subglobose; hilum pale; germ green. Grown two seasons.

22503. From Yokohama, Japan, 1908. Plants stout, erect, bushy; height 12 to 16 inches; medium; pubescence gray; flowers purple; pods large, 2¼ to 2½ inches long, tumid, crowded, shattering moderately; seeds straw-yellow, large, 9½ to 10 mm. long, subglobose; hilum pale; germ yellow. Grown two seasons.

22504. From Yokohama, Japan, 1908. Plants stout, erect, bushy; height 18 to 24 inches; late; pubescence tawny; flowers purple; pods large, 2¼ to 2½ inches long, tumid, crowded, shattering much; seeds olive-yellow, large, 8 to 9 mm. long, subglobose; hilum pale; germ yellow. Grown two seasons.

22504 A. A selection out of the original seed 22504, Plants stout, erect, bushy; height 14 to 18 inches; medium; pubescence gray; flowers purple; pods medium-sized, 1½ to 2 inches long, tumid, crowded, shattering little; seeds straw-yellow, medium-sized, 8 to 8½ mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown two seasons.

22505. From Yokohama, Japan, 1908. Plants stout, erect, bushy; height 20 to 28 inches; medium; pubescence tawny; flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, tumid, crowded, shattering little; seeds straw-yellow, medium-sized, 6½ to 7½ mm. long, elliptical, slightly flattened; hilum brown; germ yellow. Grown two seasons.

22506. From Yokohama, Japan, 1908. Plants stout, erect, bushy; height 12 to 16 inches; medium; pubescence gray; flowers purple; pods medium large, 2 to 2¼ inches long, tumid, crowded, shattering much; seeds straw-yellow, medium-sized, 8½ to 9 mm. long, elliptical, slightly flattened; hilum light brown; germ yellow. Grown two seasons.

22507. From Yokohama, Japan, 1908. Plants stout, erect, bushy; height, 18 to 22 inches; medium; pubescence tawny; flowers white; pods medium-sized, 1½ to 1¾ inches long, tumid, crowded, shattering much; seeds olive-yellow, medium large, 8½ to 9 mm. long, subglobose; hilum brown; germ yellow. Grown two seasons.

22534. From Weihsien, China, 1908. Plants slender, erect, the tips twining; height, 36 to 42 inches; late; pubescence gray; flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, compressed, half crowded, shattering moderately; seeds straw-yellow, medium small, 7½ to 8 mm. long, oval; hilum brown; germ yellow. Grown two seasons. This variety is said to be used for making lamp and cooking oil and for flour to make cakes. The remaining material after expressing the oil forms a cake which is exported for feeding animals and enriching land.

22535. From Weihsien, China, 1908. The seeds and plants of this are identical with Cloud, 16790.

22536. From Chefoo, Shantung, China, 1908. This proved identical with 17857.

22537. From Chefoo, Shantung, China, 1908. Plants stout, erect, bushy; height, 18 to 30 inches; late; pubescence tawny; flowers both purple and white; pods medium-sized, 1¾ to 2 inches long, tumid, half crowded, shattering moderately; seeds olive-yellow, medium-sized, 8½ to 9 mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown two seasons. This variety is said to be used quite extensively at Chefoo for the manufacture of oil.

22538. From Chefoo, Shantung, China, 1908. Plants slender, erect, the tips twining; height, 36 to 42 inches; medium late; pubescence gray (50 per cent) and tawny (50 per cent); flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, compressed, scattered, shattering moderately; seeds black, medium-sized, 6 to 6½ mm. long, oblong, much flattened; germ yellow. Grown two seasons.

22633. *Morgan*. From Sheklung, Kwangtung, China, 1908. Plants slender, erect, the tips twining; height, 36 to 42 inches; very late; pubescence tawny; flowers both purple and white; pods medium small, 1¼ to 1½ inches long, compressed, scattered, shattering little; seeds olive-yellow, small, 5½ to 6 mm. long, elliptical, much flattened; hilum russet; germ yellow. Grown two seasons.

22634. From Sheklung, Kwangtung, China, 1908. Plants stout, erect, bushy; height, 22 to 28 inches; medium late; pubescence tawny; flowers purple; pods medium-sized, 1¼ to 1¾ inches long, half crowded; shattering moderately; seeds black, medium small, 7½ to 8 mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown two seasons.

22644. *Stuart*. From Hangchow, Chekiang, China, 1908. Plants stout, erect, bushy; height, 36 to 40 inches; very late; pubescence gray; flowers purple; pods medium-sized, 1¾ to 2 inches long, compressed, scattered, shattering little; seeds olive-yellow, medium small, 7 to 7½ mm. long, elliptical, much flattened; hilum russet; germ yellow. Grown two seasons.

22644 A. A pure field selection in 1908. Plants stout, erect, bushy; height, 36 to 42 inches; very late; pubescence tawny; flowers purple; pods medium-sized, 1¾ to 2 inches long, compressed, scattered, shattering little; seeds seal-brown to olive, medium small, elliptical, 6½ to 7 mm. long, much flattened; hilum pale; germ yellow. Grown one season.

22644 B. *Nielsen*. A pure selection out of the original seed of 22644. Plants stout, erect, bushy; height, 34 to 38 inches; very late; pubescence gray; flowers purple; pods medium-sized, 1¾ to 2 inches long, compressed, scattered, shattering little; seeds olive-yellow, medium-sized, 7 to 7½ mm. long, elliptical, slightly flattened; hilum burnt umber; germ yellow. Grown two seasons.

22644 C. A selection in 1908. Plants stout, erect, bushy; height, 24 to 30 inches; very late; pubescence gray; flowers both purple and white; pods medium-sized, 1½ to 2 inches long, compressed, scattered, shattering little; seeds olive-yellow, medium-sized, 7 to 7½ mm. long, elliptical, much flattened; hilum brown; germ yellow. Grown one season.

22645. From Hangchow, Chekiang, China, 1908. Plants stout, erect, bushy; height, 16 to 20 inches; medium; pubescence tawny; flowers purple; pods medium large, 2 to 2¼ inches long, tumid, half crowded, shattering moderately; seeds olive-yellow, medium-sized, 7½ to 8 mm. long, elliptical, much flattened; hilum bister brown; germ yellow. Grown two seasons.

22646. From Hangchow, Chekiang, China, 1908. Plants stout, erect, bushy; height, 30 to 36 inches; very late; pubescence gray; flowers purple; medium-sized pods large, 2 to 2½ inches long, compressed, scattered, shattering little; seeds olive-yellow, large, 8 to 9 mm. long, elliptical, much flattened; hilum russet; germ yellow. Grown two seasons.

22714. From Saigon, Cochin China, 1908. Plants stout, erect, bushy; height, 30 to 36 inches; very late; pubescence gray; flowers both purple and white; pods scattered; seeds straw-yellow, medium-sized, 7½ to 8 mm. long, elliptical, much flattened; hilum light brown; germ yellow. Grown two seasons.

22874. *Vireo.* From Tokyo, Japan, 1908. Plants stout, erect, bushy; height, 14 to 18 inches; early; pubescence tawny; flowers both purple and white; pods medium-sized, 1½ to 2 inches long, tumid, crowded, shattering little; seeds olive-yellow, medium small, 6 to 6½ mm. long, elliptical, slightly flattened; hilum slate-color; germ yellow; leaves persist when pods are ripening. Grown two seasons.

22875. From Tokyo, Japan, 1908. This proved the same as Flat King, 17252.

22876. From Tokyo, Japan, 1908. Plants stout, erect, bushy; height, 16 to 22 inches; medium; pubescence gray and very sparse; flowers purple; pods medium-sized, 1½ to 2 inches long, tumid, half crowded, shattering little; seeds straw-yellow, small to medium, 6½ to 7½ mm. long, elliptical, slightly flattened; hilum brown; germ yellow. Grown two seasons.

22877. From Tokyo, Japan, 1908. This was found to be the same as Okute, 19986.

22878. From Tokyo, Japan, 1908. This did not differ in any respect from 17273.

22879. From Tokyo, Japan, 1908. Plants stout, erect, bushy; height, 20 to 26 inches; medium; pubescence gray; flowers both purple and white; pods medium small, 1¾ to 2 inches long, tumid, half crowded, shattering little; seeds straw-yellow, medium small, 6½ to 7 mm. long, elliptical, much flattened; hilum light to seal-brown; germ yellow. Grown two seasons.

22880. From Tokyo, Japan, 1908. Plants stout, erect, bushy; height, 18 to 22 inches; medium; pubescence gray (60 per cent) and tawny (40 per cent); flowers both purple and white; pods medium-sized, 1¾ to 2 inches long, compressed, half crowded, shattering little; seeds straw-yellow, medium-sized, 7½ to 8 mm. long, elliptical, much flattened; hilum pale to brown; germ yellow. Grown two seasons.

22880 A. A selection in 1908. Plants stout, erect, bushy; height, 28 to 32 inches; medium early; pubescence gray; flowers both purple and white; pods medium large, 2 to 2½ inches long, tumid, scattered, shattering little; seeds straw-yellow (cloudy saddle); medium large, 8 to 8½ mm. long, elliptical, much flattened; hilum brown; germ yellow. Grown one season.

22880 B. A selection in 1908. Plants stout, erect, bushy; height, 12 to 16 inches; medium early; pubescence gray; flowers purple; pods medium-sized, 1½ to 2 inches long, compressed, crowded, shattering little; seeds chromium green, medium-sized, 7½ to 8 mm. long, elliptical, much flattened; hilum brown; germ green. Grown one season.

22880 C. A selection in 1908. Plants stout, erect, bushy; height, 14 to 18 inches; yellow; pubescence tawny; flowers purple; pods medium-sized, 1½ to 2 inches long, tumid, half crowded, shattering little; seeds straw-yellow (cloudy); medium-sized, 6½ to 7 mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown one season.

22881. From Tokyo, Japan, 1908. Identical with Hope, 17267.

22535. From Weihsien, China, 1908. The seeds and plants of this are identical with Cloud, 16790.

22536. From Chefoo, Shantung, China, 1908. This proved identical with 17857.

22537. From Chefoo, Shantung, China, 1908. Plants stout, erect, bushy; height, 18 to 30 inches; late; pubescence tawny; flowers both purple and white; pods medium-sized, 1¾ to 2 inches long, tumid, half crowded, shattering moderately; seeds olive-yellow, medium-sized, 8½ to 9 mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown two seasons. This variety is said to be used quite extensively at Chefoo for the manufacture of oil.

22538. From Chefoo, Shantung, China, 1908. Plants slender, erect, the tips twining; height, 36 to 42 inches; medium late; pubescence gray (50 per cent) and tawny (50 per cent); flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, compressed, scattered, shattering moderately; seeds black, medium-sized, 6 to 6½ mm. long, oblong, much flattened; germ yellow. Grown two seasons.

22633. *Morgan.* From Sheklung, Kwangtung, China, 1908. Plants slender, erect, the tips twining; height, 36 to 42 inches; very late; pubescence tawny; flowers both purple and white; pods medium small, 1¼ to 1½ inches long, compressed, scattered, shattering little; seeds olive-yellow, small, 5½ to 6 mm. long, elliptical, much flattened; hilum russet; germ yellow. Grown two seasons.

22634. From Sheklung, Kwangtung, China, 1908. Plants stout, erect, bushy; height, 22 to 28 inches; medium late; pubescence tawny; flowers purple; pods medium-sized, 1¼ to 1¾ inches long, half crowded; shattering moderately; seeds black, medium small, 7½ to 8 mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown two seasons.

22644. *Stuart.* From Hangchow, Chekiang, China, 1908. Plants stout, erect, bushy; height, 36 to 40 inches; very late; pubescence gray; flowers purple; pods medium-sized, 1¾ to 2 inches long, compressed, scattered, shattering little; seeds olive-yellow, medium small, 7 to 7½ mm. long, elliptical, much flattened; hilum russet; germ yellow. Grown two seasons.

22644 A. A pure field selection in 1908. Plants stout, erect, bushy; height, 36 to 42 inches; very late; pubescence tawny; flowers purple; pods medium-sized, 1¾ to 2 inches long, compressed, scattered, shattering little; seeds seal-brown to olive, medium small, elliptical, 6½ to 7 mm. long, much flattened; hilum pale; germ yellow. Grown one season.

22644 B. *Nielsen.* A pure selection out of the original seed of 22644. Plants stout, erect, bushy; height, 34 to 38 inches; very late; pubescence gray; flowers purple; pods medium-sized, 1¾ to 2 inches long, compressed, scattered, shattering little; seeds olive-yellow, medium-sized, 7 to 7½ mm. long, elliptical, slightly flattened; hilum burnt umber; germ yellow. Grown two seasons.

22644 C. A selection in 1908. Plants stout, erect, bushy; height, 24 to 30 inches; very late; pubescence gray; flowers both purple and white; pods medium-sized, 1½ to 2 inches long, compressed, scattered, shattering little; seeds olive-yellow, medium-sized, 7 to 7½ mm. long, elliptical, much flattened; hilum brown; germ yellow. Grown one season.

22645. From Hangchow, Chekiang, China, 1908. Plants stout, erect, bushy; height, 16 to 20 inches; medium; pubescence tawny; flowers purple; pods medium large, 2 to 2¼ inches long, tumid, half crowded, shattering moderately; seeds olive-yellow, medium-sized, 7½ to 8 mm. long, elliptical, much flattened; hilum bister brown; germ yellow. Grown two seasons.

22646. From Hangchow, Chekiang, China, 1908. Plants stout, erect, bushy; height, 30 to 36 inches; very late; pubescence gray; flowers purple; medium-sized pods large, 2 to 2½ inches long, compressed, scattered, shattering little; seeds olive-yellow, large, 8 to 9 mm. long, elliptical, much flattened; hilum russet; germ yellow. Grown two seasons.

22714. From Saigon, Cochin China, 1908. Plants stout, erect, bushy; height, 30 to 36 inches; very late; pubescence gray; flowers both purple and white; pods scattered; seeds straw-yellow, medium-sized, 7½ to 8 mm. long, elliptical, much flattened; hilum light brown; germ yellow. Grown two seasons.

22874. *Vireo.* From Tokyo, Japan, 1908. Plants stout, erect, bushy; height, 14 to 18 inches; early; pubescence tawny; flowers both purple and white; pods medium-sized, 1½ to 2 inches long, tumid, crowded, shattering little; seeds olive-yellow, medium small, 6 to 6½ mm. long, elliptical, slightly flattened; hilum slate-color; germ yellow; leaves persist when pods are ripening. Grown two seasons.

22875. From Tokyo, Japan, 1908. This proved the same as Flat King, 17252.

22876. From Tokyo, Japan, 1908. Plants stout, erect, bushy; height, 16 to 22 inches; medium; pubescence gray and very sparse; flowers purple; pods medium-sized, 1½ to 2 inches long, tumid, half crowded, shattering little; seeds straw-yellow, small to medium, 6½ to 7½ mm. long, elliptical, slightly flattened; hilum brown; germ yellow. Grown two seasons.

22877. From Tokyo, Japan, 1908. This was found to be the same as Okute, 19986.

22878. From Tokyo, Japan, 1908. This did not differ in any respect from 17273.

22879. From Tokyo, Japan, 1908. Plants stout, erect, bushy; height, 20 to 26 inches; medium; pubescence gray; flowers both purple and white; pods medium small, 1¾ to 2 inches long, tumid, half crowded, shattering little; seeds straw-yellow, medium small, 6½ to 7 mm. long, elliptical, much flattened; hilum light to seal-brown; germ yellow. Grown two seasons.

22880. From Tokyo, Japan, 1908. Plants stout, erect, bushy; height, 18 to 22 inches; medium; pubescence gray (60 per cent) and tawny (40 per cent); flowers both purple and white; pods medium-sized, 1¾ to 2 inches long, compressed, half crowded, shattering little; seeds straw-yellow, medium-sized, 7½ to 8 mm. long, elliptical, much flattened; hilum pale to brown; germ yellow. Grown two seasons.

22880 A. A selection in 1908. Plants stout, erect, bushy; height, 28 to 32 inches; medium early; pubescence gray; flowers both purple and white; pods medium large, 2 to 2½ inches long, tumid, scattered, shattering little; seeds straw-yellow (cloudy saddle); medium large, 8 to 8½ mm. long, elliptical, much flattened; hilum brown; germ yellow. Grown one season.

22880 B. A selection in 1908. Plants stout, erect, bushy; height, 12 to 16 inches; medium early; pubescence gray; flowers purple; pods medium-sized, 1½ to 2 inches long, compressed, crowded, shattering little; seeds chromium green, medium-sized, 7½ to 8 mm. long, elliptical, much flattened; hilum brown; germ green. Grown one season.

22880 C. A selection in 1908. Plants stout, erect, bushy; height, 14 to 18 inches; yellow; pubescence tawny; flowers purple; pods medium-sized, 1½ to 2 inches long, tumid, half crowded, shattering little; seeds straw-yellow (cloudy); medium-sized, 6½ to 7 mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown one season.

22881. From Tokyo, Japan, 1908. Identical with Hope, 17267.

23207 B. A pure selection out of the original seed. Plants stout, erect, bushy; height 30 to 34 inches; very late; pubescence tawny; flowers white; pods large, $2\frac{1}{4}$ to $2\frac{3}{4}$ inches long, compressed, crowded, shattering little; seeds straw-yellow, large, 9 to $9\frac{1}{2}$ mm. long, elliptical, much flattened; hilum seal-brown; germ yellow. Grown one season.

23208. From Tangsi, Chekiang, China, 1908. Plants slender, suberect, the tips twining; height 30 to 36 inches; very late; pubescence gray; flowers purple; pods large, half crowded; seeds straw-yellow, large, $7\frac{1}{2}$ to 8 mm. long, elliptical, slightly flattened; hilum brown; germ yellow. Grown one season.

23209. From Tangsi, Chekiang, China, 1908. Plants stout, erect, bushy; height 24 to 28 inches; very late; pubescence gray and tawny; flowers purple; pods medium large, 2 to $2\frac{1}{4}$ inches long, compressed, half crowded, shattering little; seeds straw-yellow, medium large, 8 to $8\frac{1}{2}$ mm. long, elliptical, slightly flattened; hilum brown; germ yellow. Grown two seasons.

23209 A. A pure selection out of the original seed. Plants stout, erect, bushy; height 36 inches; very late; pubescence tawny; flowers white; pods medium-sized, 2 to $2\frac{1}{4}$ inches long, compressed, scattered, shattering little; seeds chromium green, medium-sized, 7 to $7\frac{1}{2}$ mm. long, elliptical, slightly flattened; hilum brown; germ green. Grown one season.

23211. From Tangsi, Chekiang, China, 1908. Plants slender, erect, the tips twining; height 30 to 36 inches; very late; pubescence both gray and tawny; flowers purple; pods large, 2 to $2\frac{1}{2}$ inches long, compressed, half crowded, shattering little; seeds deep brown, medium large, 7 to 8 mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown two seasons.

23212. From Hangchow, Chekiang, China, 1908. Seeds yellow, but none germinated.

23213. From Hangchow, Chekiang, China, 1908. Plants slender, erect, the tips twining; height 24 to 30 inches; very late; pubescence tawny; flowers purple; pods half crowded; seeds straw-yellow, large, 8 to $8\frac{1}{2}$ mm. long, oval; hilum prominent seal-brown; germ yellow. Grown one season.

23213 A. A selection out of the original seed. Plants stout, erect, bushy; height 20 to 24 inches; very late; pubescence tawny; flowers purple and white; pods half crowded; seeds yellow and black, medium large, $7\frac{1}{2}$ to 8 mm. long, elliptical, slightly flattened; hilum seal-brown; germ yellow. Grown one season.

23229. *Sedo.* From Tientsin, Chihli, China, 1908. Plants stout, erect, bushy; height 20 to 26 inches; medium; pubescence tawny; flowers purple; pods medium large, $1\frac{3}{4}$ to $2\frac{1}{4}$ inches long, tumid scattered, shattering little; seeds deep brown, very large, 9 to 10 mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown two seasons. This variety is said to be rare and used only for human food.

23232. From Chinhuafu, Kiangsu, China, 1908. Plants slender, erect, the tips twining; height 34 to 40 inches; very late; pubescence tawny; flowers purple; pods small. $1\frac{1}{8}$ to $1\frac{1}{2}$ inches long, compressed, scattered, shattering little; seeds dull brown, small, $5\frac{1}{2}$ to 6 mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown two seasons. This variety is said tc be grown on wet rice lands throughout central China.

23291. From Wutaishan, Shansi, China, 1908. Plants slender, erect, the tips twining; height 30 to 42 inches; medium late; pubescence gray (50 per cent) and tawny (50 per cent); flowers purple; pods medium small, 1¼ to 1¾ inches long, compressed, scattered, shattering little; seeds black, medium-sized, 7 to 8 mm. long, oblong, much flattened; germ yellow. Grown one season. "This variety is considered by the Chinese to be the best food for their hard-working horses and mules."

23292. From Wutaishan, Shansi, China, 1908. Plants stout, erect, bushy; height 18 to 24 inches; medium; pubescence tawny; flowers purple; pods medium-sized, 1¾ to 2 inches long, compressed, half crowded, shattering little; seeds small to medium, 7½ to 8 mm. long, elliptical, much flattened; hilum brown. Grown two seasons. This variety is said to be used all through northern China for making bean curd and bean vermicelli.

23292 A. A selection out of the original seed. Plants stout, erect, bushy; height 26 to 30 inches; medium; pubescence tawny; flowers purple; pods medium-sized; 1½ to 1¾ inches long, compressed, scattered, shattering little; seeds medium-sized, 7 to 8 mm. long, oblong, much flattened; germ yellow. Grown one season.

23292 B. A selection out of the original seed. Plants slender, erect, the tips twining; height 24 to 30 inches; medium; pubescence tawny; flowers purple; pods medium-sized, 1½ to 2 inches long, compressed, half crowded, shattering moderately; seeds brown, medium-sized, 7½ to 8 mm. long, oblong, much flattened; hilum pale; germ yellow. Grown one season.

23292 C. A selection out of the original seed. Plants stout, erect, bushy; height 28 to 34 inches; late; pubescence tawny; flowers purple; pods medium-sized, 1¾ to 2 inches long, compressed, scattered, shattering little; seeds chromium green, medium-sized, 7½ to 8 mm. long, oblong, much flattened; hilum seal-brown; germ green. Grown one season.

23296. From Taichow, Chekiang, China, 1908. A variety found growing on strongly alkaline lands. Plants stout, erect, bushy; height 30 to 36 inches; medium; pubescence tawny; flowers both purple and white; pods medium sized, 1¾ to 2 inches long, tumid, half crowded, shattering little; seeds straw-yellow, medium-sized, 8½ to 9 mm. long, elliptical much flattened; hilum slate-black; germ yellow. Grown two seasons.

23296 A. A selection out of the original seed. Plants stout, erect, bushy; height 24 to 30 inches; medium late; pubescence tawny; flowers white; pods medium large, 1¾ to 2 inches long, compressed, half crowded, shattering moderately; seeds chromium green, medium large, 9 to 10 mm. long, elliptical, much flattened; hilum bister brown; germ green. Grown one season.

23296 C. A selection out of the original seed. Plants stout, erect, bushy; height 20 to 24 inches; medium; pubescence gray; flowers purple; pods medium-sized, 1½ to 1¾ inches long, compressed, half crowded, shattering little; seeds black, medium-sized, 8½ to 9 mm. long, oblong, much flattened; hilum pale; germ yellow. Grown one season.

23297. From Taichow, China, 1908. Plants slender, erect, the tips twining; height 28 to 34 inches; medium late; pubescence gray and tawny; flowers purple, pods medium-sized, 1¾ to 2 inches long, compressed, half-crowded, shattering little; seeds black, medium-sized, 7½ to 8 mm. long, oblong, much flattened; hilum pale; germ yellow. Grown two seasons.

23297 A. A selection out of the original seed. Plants slender, erect, the tips twining; height 30 to 36 inches; medium late; pubescence tawny; flowers both purple and white; pods large, 1¾ to 2¼ inches long, tumid, half crowded, shattering little; seeds brown, large, 8 to 8½ mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown one season.

23297 B. A selection out of the original seed. Plants slender, suberect, the tips twining; height 30 to 36 inches; medium late; pubescence tawny; flowers both purple and white; pods medium-sized, 1½ to 2 inches long, compressed, half crowded, shattering little; seeds straw-yellow, medium-sized, 8½ to 9 mm. long, oblong, much flattened; hilum slate-black; germ yellow. Grown two seasons.

23299. From Tsintse, China, 1908. Plants slender, erect, the tips twining; height 42 to 48 inches; late; pubescence tawny; flowers purple; pods large, 2 to 2¼ inches long, tumid, scattered, shattering little; seed black with yellow saddle, large, 9 to 9½ mm. long, elliptical, much flattened; hilum black; germ yellow. Grown one season. This is said to be a rare local variety of soy bean used as a vegetable when slightly sprouted.

23303. From Shiling, Chihli, China, 1908. Plants stout, erect, bushy; height 14 to 30 inches; medium late; pubescence gray (70 per cent) and tawny (30 per cent); flowers purple; pods medium-sized, 1¾ to 2 inches long, compressed, half crowded, shattering little; seeds straw-yellow, medium-sized, 8 to 8½ mm. long, elliptical, slightly flattened; hilum brown to nearly black; germ yellow. Grown two seasons. This variety is said to be used all through northern China for making bean curd and bean vermicelli.

23303 A. A selection out of the original seed. Plants stout, erect, bushy; height 20 to 24 inches; medium late; pubescence tawny; flowers purple; pods medium large, 1¾ to 2 inches long, compressed, half crowded, shattering little; seeds chromium green, medium-sized; 8 to 8½ mm. long, elliptical, slightly flattened; hilum black; germ green. Grown one season.

23305. From Peking, Chihli, China, 1908. Seeds yellow, but all failed to germinate.

23306. From Peking, Chihli, China, 1908. Plants stout, erect, bushy; height 30 to 36 inches; medium late; pubescence tawny; flowers white; pods large, 1¾ to 2 inches long, tumid, half crowded, shattering little; seeds black, large, 8½ to 9 mm. long, elliptical, slightly flattened; hilum pale; germ green. Grown one season.

23311. From Shiling, Chihli, China, 1908. Plants slender, erect, the tips twining; height 36 to 40 inches; late; pubescence tawny; flowers white; pods medium large, 1¾ to 2 inches long, compressed, scattered, shattering little; seeds chromium green, medium large, 7½ to 8½ mm. long, elliptical, slightly flattened; hilum slate-black; germ green. Grown one season.

23311 A. Selected out of the original seed. Plants slender, erect; height 32 to 36 inches; medium late; pubescence tawney; flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, compressed, shattering little; seeds black, medium small, 7 to 7½ mm. long, oblong, much flattened; hilum pale; germ yellow. Grown one season.

23311 B. A selection out of the original seed. Plants stout, erect, bushy; height 30 to 36 inches; pubescence tawny; flowers purple; pods medium-sized, 1¾ to 2 inches long, tumid, crowded, shattering little; seeds black and yellow, medium small, 7 to 7½ mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown one season.

23312. From Paotingfu, Chihli, China, 1908. Plants slender, erect; height 24 to 30 inches; medium late; pubescence gray; flowers both purple and white; pods medium small, 1¼ to 1½ inches long, tumid, shattering little; seeds olive-yellow, small, 6 to 6½ mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown two seasons.

23325. From Canton, Kwangtung, China, 1908. Plants stout, erect, bushy; height 12 to 16 inches; medium late; pubescence tawny; flowers purple; pods medium small, 1½ to 1¾ inches long, tumid, crowded, shattering moderately; seeds black, small, 6 to 6½ mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown one season.

23326. From Canton, Kwangtung, China. Seeds olive-yellow; all failed to germinate.

23327. From Canton, Kwangtung, China, 1908. Seeds olive-yellow; none germinated.

23336. From Shanghai, Kiangsu, China, 1908. This is the same as 20798, secured at the same place.

23337. From Shanghai, Kiangsu, China, 1908. Identical with 20797, from the same place.

23338. From Shanghai, Kiangsu, China, 1908. Plants slender, erect, very leafy; height 48 to 60 inches; very late; pubescence tawny; flowers purple; pods medium-sized, 1½ to 2 inches long, tumid, scattered, shattering little; seeds brown with more or less black usually in concentric bands, medium-sized, 7½ to 8 mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown one season. Notes taken at Jackson, Tenn.

23338 B. A selection out of the original seed. Plants slender, erect, the tips twining; height 30 to 40 inches; very late; pubescence tawny; flowers purple; pods scattered; seeds black, large, 8 to 9 mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown one season.

23522. From Chungking, Szechwan, China, 1908. Seeds olive-yellow; none germinated.

23523. From Chungking, Szechwan, China, 1908. Plants stout, erect, bushy; height 14 to 20 inches; late; pubescence tawny; flowers purple; pods medium-sized, 1½ to 1¾ inches long, tumid, crowded, shattering moderately; seeds black, medium-sized, 6½ to 7½ mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown one season.

23544. From Ningyuenfu, Szechwan, China, 1908. Seeds yellow; none viable.

23545. From Ningyuenfu, Szechwan, China, 1908. Seeds yellow; none grew.

23546. From Ningyuenfu, Szechwan, China, 1908. Plants stout, erect, bushy; height 38 to 42 inches; very late; pubescence tawny; flowers purple; pods small, 1⅜ to 1½ inches long, compressed, scattered, shattering little; seeds black, very small, 5 to 5½ mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown one season.

24180. From Soochow, Kiangsu, China, 1908. Plants stout, erect, bushy; height 14 to 20 inches; medium late; pubescence tawny; flowers purple; pods large, 2¼ to 2½ inches long, tumid, crowded, shattering moderately; seeds black, large, 9 to 9½ mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown one season.

24181. From Soochow, Kiangsu, China, 1908. Plants stout, erect, bushy; height 18 to 24 inches; medium; pubescence gray; flowers purple; pods medium-sized, 1¾ to 2 inches long, tumid, half-crowded, shattering little; seeds straw-yellow, medium large, 8 to 8½ mm. long, elliptical, much flattened; hilum brown; germ yellow. Grown one season.

24182. From Soochow, Kiangsu, China, 1908. Seeds green; none viable.

24183. From Soochow, Kiangsu, China, 1908. Plants stout, erect, bushy; height 16 to 20 inches; medium late; pubescence gray; flowers purple; pods large, 2 to 2¼ inches long, tumid, crowded, shattering little; seeds olive-yellow, medium-sized, 9 to 9½ mm. long, elliptical, slightly flattened; hilum brown; germ yellow; leaves persist when pods are ripening. Grown one season.

24184. From Soochow, Kiangsu, China, 1908. Plants slender, erect, the tips twining; height 36 to 42 inches; late; pubescence gray; flowers purple; pods medium-sized, 1½ to 2 inches long, compressed, scattered, shattering little; seeds straw-yellow, medium-sized, 7 to 7½ mm. long, elliptical, slightly flattened; hilum light brown; germ yellow. Grown one season.

24610. *Trenton.* From Trenton, Ky. Found by Mr. S. J. Leavell in a field of the Mammoth variety in 1904. Plants stout, erect, bushy; height 32 to 38 inches; late; pubescence gray; flowers white; pods medium-sized, 1½ to 2 inches long, compressed, scattered, shattering little; seeds brown, medium small, 6½ to 7 mm. long, elliptical, much flattened; hilum pale; germ yellow. Except for color and shape of seeds, this variety is indistinguishable from Mammoth, 17280. Grown one season.

24641. From Taihoku, Formosa, 1909. Seeds yellow; all failed to germinate.

24642. From Taihoku, Formosa, 1909. Plants procumbent, vining, rather coarse; stems 52 to 60 inches long; very late; pubescence tawny; flowers purple; pods small, 1¼ to 1½ inches long, tumid, scattered, shattering little; seeds black, small, 5 to 5½ mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown one season. A variety identical with this was received under No. 24643 (Taihoku, Formosa).

24643. From Taihoku, Formosa, 1909. Seeds black; none grew.

24672. From Khasi Hills, Assam, India, 1909. Plants stout, erect, bushy; height 42 to 48 inches; very late; pubescence tawny; flowers purple; pods small, 1¼ to 1½ inches long, compressed, scattered, shattering little; seeds yellow, clouded with brown, small, 5½ to 6 mm. long, elliptical, much flattened; hilum brown; germ yellow. Grown one season.

24672 A. A selection out of the original seed. Plants slender, erect, the tips twining; height 36 to 42 inches; very late; pubescence tawny; flowers purple; pods small, 1⅓ to 1½ inches long, tumid, scattered, shattering little; seeds brown, small, 5½ to 6 mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown one season.

24672 B. A selection out of the original seed. Plants stout, erect, bushy; height 24 to 32 inches; very late; pubescence tawny; flowers purple; pods small, 1 to 1¼ inches long, tumid, scattered, shattering little; seeds straw-yellow, small, 5½ to 6 mm. long, elliptical, much flattened; hilum brown; germ yellow. Grown one season.

24673. From Darjiling, Assam, India, 1909. Plants procumbent, vining, rather coarse; stems 48 to 60 inches long; very late; pubescence tawny; flowers purple; pods small, 1¼ to 1½ inches long, compressed, scattered, shattering little; seeds brown, small, 5 to 5½ mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown one season.

24674. From Darjiling, Assam, India, 1909. Plants procumbent, vining, rather coarse; stems 48 to 56 inches long; very late; pubescence tawny; flowers purple; pods medium small, 1¼ to 1¾ inches long, compressed, scattered, shattering little; seeds straw-yellow, small, 6 to 6½ mm. long, elliptical, much flattened; hilum brown; germ yellow. Grown one season.

24675. From Safipur, Unao, United Provinces, India, 1909. Plants procumbent, vining, rather coarse; stems 48 to 60 inches long; very late; pubescence tawny; flowers purple; pods small, 1¼ to 1½ inches long, compressed, scattered, shattering little; seeds black, small, 5½ to 6 mm. long, oblong, much flattened; germ yellow. Grown one season. The following lots, all from India, were found to be identical with this: 24676, from Hasangani; 24677, from Ranjitpurwa; 24678, 24679, 24680, 24683, 24686, from Etawah; 24681, from Mainpuri; 24688, from Cawnpore; 24689, from Dehra Dun.

24676. From Hasangani, Unao, U. P., India. Identical with 24675.

24677. From Ranjitpurwa, Unao, U. P., India. Identical with 24675.

24678. From Etawah, Unao, U. P., India. Identical with 24675.

24679. From Etawah, Unao, U. P., India. Identical with 24675.

24680. From Etawah, Unao, U. P., India. Identical with 24675.

24681. From Mainpuri, U. P., India. Identical with 24675.

24682. From Mainpuri, U. P., India, 1909. Plants stout, erect, bushy; height 18 to 24 inches; very late; pubescence tawny; flowers purple; pods small, 1¼ to 1½ inches long, compressed, scattered, shattering little; seeds black, very small, 5 to 5½ mm. long, oblong, much flattened; germ yellow. Grown one season. Nos. 24684 and 24685, from Etawah, India, are identical with this variety.

24683. From Etawah, Unao, U. P., India. Identical with 24675.

24684. From Etawah, Unao, U. P., India. Identical with 24682.

24685. From Etawah, Unao, U. P., India. Identical with 24682.

24686. From Etawah, Unao, U. P., India. Identical with 24675.

24687. From United Provinces, India. Did not germinate.

24688. From Cawnpore, India. This proved to be identical with No. 24675.

24689 From Cawnpore, India. This is identical with No. 24675.

24690. From Dehra Dun, U. P., India. Did not germinate.

24693 to 24711, inclusive. Nineteen Japanese varieties of soy beans grown on Poona Farm, Bombay Presidency, India. All of these failed to germinate, except 24695.

24695. From Poona, Bombay, India, 1909, originally from Japan. Plants stout, erect, bushy; height 28 to 32 inches; late; pubescence gray; flowers purple; pods medium-sized, 1¾ to 2 inches long, compressed, crowded, shattering little; seeds straw-yellow, medium-sized, 7 to 7¼ mm. long; elliptical, much flattened; hilum pale; germ yellow. Grown one season.

24839. From Shanghai, Kiangsu, China, 1906. Plants stout, erect, bushy; height 32 to 36 inches; very late; pubescence tawny; flowers white; pods large, 2¼ to 2½ inches long, compressed, scattered, shattering little; seeds olive-yellow, medium large, 7½ to 8 mm. long; elliptical, slightly flattened; hilum slate-black; germ yellow. Grown four seasons.

24840. From Shanghai, China, 1906. Plants stout, erect, bushy; height 32 to 36 inches; very late; pubescence gray; flowers purple; pods large, 1¾ to 2¼ inches long, tumid, scattered, shattering little; seeds straw-yellow, large, 8½ to 9 mm. long, elliptical, slightly flattened; hilum seal-brown; germ yellow. Grown three seasons.

25093. *Mammoth.* From Hickory, N. C.

25118. From Pithoragarh, Kumaon District, India, 1909. Plants procumbent, vining, rather coarse; stems 48 to 60 inches long; very late; pubescence tawny; flowers purple; pods small, 1½ to 1¾ inches long, compressed, scattered, shattering little; seeds black, marbled with brown, small, 5 to 6 mm. long, oblong, much flattened; hilum pale; germ yellow. Grown one season.

25130. *Early Brown.* From Knoxville, Tenn, 1909. Plants stout, erect, bushy; height 18 to 24 inches; medium early; pubescence tawny; flowers purple; pods medium-sized, 2 to 2½ inches long, tumid, half crowded, shattering little; seeds brown, medium-sized, 7½ to 8 mm. long, elliptical, much flattened; hilum pale; germ yellow. Except for color of seeds and maturity, this variety is difficult to distinguish from Ito San, 17268. Grown one season. No. 25161, from the Indiana Agricultural Experiment Station, is the same.

25131. From Knoxville, Tenn., 1909. Plants stout, erect, bushy; height 30 to 36 inches; medium late; pubescence tawny; flowers purple; pods medium-sized, 1¾ to 2½ inches long, compressed, half crowded, shattering much; seeds straw-yellow, medium-sized, 7 to 7½ mm. long, elliptical, much flattened; hilum light brown; germ yellow. Grown one season.

25133. From Soochow, China, 1909. Plants slender, suberect, the tips twining; stems 48 to 60 inches long; very late; pubescence both gray and tawny; flowers purple; pods scattered; seeds straw-yellow, small, 5½ to 6 mm. long, elliptical, much flattened; hilum light brown; germ yellow. Grown one season. This variety is said to be the smallest grown at Soochow, and is used only for bean sprouts.

25134. From Soochow, China, 1909. Plants slender, suberect, the tips twining; stems 36 to 42 inches long; very late; pubescence gray; flowers purple; pods large, 2½ to 2¾ inches long, compressed, scattered; seeds straw-yellow, large, 9 to 9½ mm. long, elliptical, slightly flattened; hilum light brown; germ yellow. Grown one season.

25134 A. A selection out of the original seed. Plants slender, suberect, the tips twining; stems 42 to 48 inches long; very late; pubescence tawny; flowers both purple and white; pods medium-sized, 1¼ to 1¾ inches long, tumid, scattered, shattering little; seeds straw-yellow, medium-sized, 8 to 8½ mm. long, elliptical, slightly flattened; hilum light to dark brown; germ yellow. Grown one season.

25135. From Soochow, Kiangsu, China, 1909. Plants slender, erect, the tips twining; height 40 to 46 inches; very late; pubescence tawny; flowers purple; pods large, 2 to 2½ inches long, scattered, shattering little; seeds chromium green, large, 7½ to 8 mm. long, elliptical, slightly flattened; hilum slate-colored; germ green. Grown one season. This variety may be put to all uses of the soy, but in practice it is used only to make parched Sutt beans, eaten as a relish.

25136. From Soochow, Kiangsu, China, 1909. Plants slender, suberect, the tips twining; stems 48 to 56 inches long; very late; pubescence tawny; flowers purple; pods large, 2½ to 2¾ inches long, compressed, scattered, shattering little; seeds brown, very large, 9 to 10 mm. long; elliptical, slightly flattened; hilum pale; germ yellow. Grown one season. This variety is said to be the largest of all the soys at Soochow. It is used only for eating in the green state, but may be used for all the soy purposes.

25137. From Soochow, Kiangsu, China, 1909. Plants procumbent, vining, rather coarse; stems 36 to 42 inches long; very late; pubescence tawny; flowers purple; pods scattered; seeds brown and black, the colors concentrated in bands, large, 9 to 9½ mm. long, elliptical, slightly flattened; hilum pale; germ yellow. Grown one season.

25138. From Soochow, Kiangsu, China, 1909. This is identical with the wild soy bean, No. 22428. Grown one season. (See Pl. II, fig. 1.)

25161. *Early Brown.* From Indiana Agricultural Experiment Station, 1909. Identical with 25130.

This variety was obtained originally by the Indiana Agricultural Experiment Station from Mr. E. F. Diehl, Leesburg, Ind., who writes that he had two varieties, an Early Yellow and the Early Black, which he tested side by side. In the progeny, he noted a few seeds that were partly brown and yellow in color, the one gradually shading into the other. Out of curiosity, he selected and planted the seeds with the largest amount of brown and within a few years secured the brown-seeded variety which has been called Early Brown.

Among seeds of the Ito San variety grown at the Kansas Agricultural Experiment Station were many in which the seed was partially brown, undoubtedly due to the influence of crossing.

25162. *Mammoth.* From Columbia, Tenn.

25212. From Botanic Gardens, Bremen, Germany, 1909. This proved to be the same as 21755.

25212 A. Black seeds mixed with the preceding. Produced plants identical with Buckshot, 17251.

25437. From Yachow, Szechwan, China, 1909. Plants slender, erect, the tips twining; height 48 to 56 inches; very late; pubescence gray (60 per cent) and tawny (40 per cent); flowers white; pods medium-sized, 1½ to 1¾ inches long, compressed, scattered, shattering little; seeds straw-yellow, medium-sized, 6 to 6½ mm. long, elliptical, slightly flattened; hilum light brown; germ yellow. Grown one season.

25437 A. A selection out of the original seed. Plants stout, erect, bushy; height 32 to 38 inches; very late; pubescence tawny; flowers purple; pods medium-sized, 1½ to 1¾ inches long, compressed, scattered, shattering little; seeds chromium green, medium-sized, 6½ to 7 mm. long; elliptical, slightly flattened hilum russet; germ green. Grown one season.

25437 B. A selection from the original seed. Plants stout, erect, bushy; height 26 to 32 inches; very late; pubescence tawny; flowers white; pods medium-sized, 1¾ to 2 inches long, compressed, half crowded; shattering little; seeds black, medium-sized, 6 to 7 mm. long, elliptical, slightly flattened; hilum pale; germ green. Grown one season.

25437 C. A selection out of the original seed. Plants stout, erect, bushy; height 36 to 40 inches; very late; pubescence tawny; flowers both purple and white; pods medium-sized, 1¾ to 2 inches long, compressed, half crowded, shattering little; seeds brown, medium-sized, 6½ to 7 mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown one season.

25438. From Yachow, Szechwan, China, 1909. Plants slender, erect, the tips twining; height 30 to 36 inches; very late; pubescence tawny; flowers white; pods medium-sized, 1¾ to 2 inches long, compressed, scattered, shattering little; seeds chromium green, medium small, 6 to 7 mm. long, elliptical, slightly flattened; hilum slate-colored; germ green. Grown one season.

25438 A. A selection out of the original seed. Plants slender, erect, the tips twining; height 34 to 38 inches; very late; pubescence both gray and tawny; flowers both purple and white; pods medium large, 1¾ to 2¼ inches long, compressed, scattered, shattering little; seeds olive-yellow, medium-sized, 6½ to 7½ mm. long, elliptical, slightly flattened; hilum light brown; germ yellow. Grown one season.

25438 B. A selection out of the original seed. Plants slender, erect, the tips twining; height 36 to 40 inches; very late; pubescence both gray and tawny; flowers white; pods medium-sized, 1½ to 1¾ inches long, compressed, scattered, shattering little; seeds straw-yellow, medium-sized, 7 to 7½ mm. long, elliptical, slightly flattened; hilum seal-brown; germ yellow. Grown one season.

25468. *Wisconsin Black.* From L. L. Olds Seed Company, Madison, Wis., 1909, secured by that company from the Wisconsin Agricultural Experiment Station. Plants stout, erect, bushy; height 16 to 20 inches; medium; pubescence tawny; flowers purple; pods medium-sized, 1½ to 1¾ inches long, compressed, half crowded, shattering little; seeds black, medium-sized, 8 to 8½ mm. long, elliptical, much flattened; hilum pale; germ yellow. Grown nine seasons. This variety has proved to be one of the earliest growing in Wisconsin. While the records are somewhat incomplete, it is almost certainly the direct descendant of S. P. I. No. 5039, received from Vilmorin-Andrieux & Co., Paris, France, 1900.

27498. From Peking, Chihli, China, 1909. Plants slender, erect, the tips twining; height 42 to 48 inches; late; pubescence gray; flowers both purple and white; pods medium-sized, 1½ to 1¾ inches long, tumid, half crowded, shattering little; seeds chromium green, medium-sized, 7 to 7½ mm. long, elliptical, slightly flattened; hilum black; germ green. Grown one season.

27499. From Ingang, Fukien, China, 1909. Plants slender, erect, the tips twining; height 36 to 42 inches; very late; pubescence tawny; flowers purple; pods scattered; seeds straw-yellow, 5½ to 6 mm. long, elliptical, slightly flattened; hilum seal-brown; germ yellow. Grown one season.

27500. From Shanghai, Kiangsu, China, 1909. Plants stout, erect, bushy; height 26 to 32 inches; very late; pubescence tawny; flowers purple; pods medium large, 2 to 2½ inches long, compressed, half crowded, shattering little; seeds straw-yellow, medium-sized, 7 to 7½ mm. long, elliptical, much flattened; hilum light brown; germ yellow. Grown one season.

27501. From Shanghai, Kiangsu, China, 1909. Plants stout, erect, bushy; height 36 to 42 inches; very late; pubescence tawny; flowers purple; pods large, 2½ to 2¾ inches long, compressed, scattered, shattering little; seeds olive-yellow, cloudy, large, 9½ to 10 mm. long, elliptical, slightly flattened; hilum black; germ yellow. Grown one season.

THE BEST VARIETIES OF SOY BEANS.

It is difficult to determine the best soy-bean varieties out of those tested, not only on account of the very large number, but also owing to the divergent results reached at the various places where they have been grown. The soy bean seems to be peculiarly subject to fluctuations brought about by change of soil or change of climate. The differences in behavior of the same pedigreed seed in different places is often very striking, so much so that it is difficult to believe that it is the same variety. Whether these differences are due mainly to climate or to soil is difficult to determine, but in general the results indicate that both factors are potent. On this account it may very well be that the final conclusions reached by experimenters as to the best varieties will depend upon the place where the experiments have been conducted. The list of the best varieties

ere given is a tentative one based primarily upon the results at Arlington Experimental Farm, but those obtained in cooperation with various experiment stations have also been given due consideration. These matters should be given careful weight by all xperimental agronomists, as otherwise it is conceivable that really valuable varieties may be overlooked or may be too hastily disarded.

Very early.—Ogemaw, 17258.

Early.—Early Brown, 25161; and Vireo, 22874.

Medium early.—Chernie, 18227; Auburn, 21079 A; Merko, 20412; Elton, 20406; Chestnut, 20405 B.

Medium.—Ito San, 17268; Medium Yellow, 17269; Tashing, 20854; Shingto, 21079; wan, 22379; Brindle, 20407; Sedo, 23229; Lowrie, 22898 A.

Medium late.—Brooks, 16789; Flava, 16789 A; Cloud, 16790; Ebony, 17254; Haberndt, 17271; Peking, 17852 B; Wilson, 19183; Taha, 21999; Austin, 17263.

Late.—Mammoth, 17280; Edward, 14953; Acme, 14954; Flat King, 17252; Tokyo, 7264; Hope, 17267; Hollybrook, 17278; Farnham, 22312.

Very late.—Barchet, 20798; Riceland, 20797.

DESCRIPTION OF PLATES.

PLATE I. Plant of the wild soy bean, No. 22428, grown in greenhouse. Note the very slender stems, vining habit, and small, scattered pods.

PLATE II. Fig. 1.—Wild soy bean from Soochow, China, No. 25138, grown at Arlington Experimental Farm, 1908. This variety could not be distinguished from No. 22428 when grown side by side. Note the slender vining stems and procumbent habit. Fig. 2.—Soy bean from Cawnpore, India, No. 24689, grown at Arlington Experimental Farm, 1909. This variety is very similar in habit to No. 25138, but is so late that it did not even bloom at Arlington.

PLATE III. Variety tests of soy beans at Arlington Experimental Farm. Note the erect, bushy habit, and differences in size and earliness.

PLATE IV. Seven varieties of soy beans, showing types of habit. No. 17852, Meyer; No. 17852 B, Peking; No. 17263, Austin; No. 18259, Pingsu; No. 22504, unnamed; No. 17278, Hollybrook; No. 17271, Haberlandt.

PLATE V. The same seven plants shown in Plate IV, after hanging in a dry room for six months. All have shattered badly but No. 17852 B, Peking.

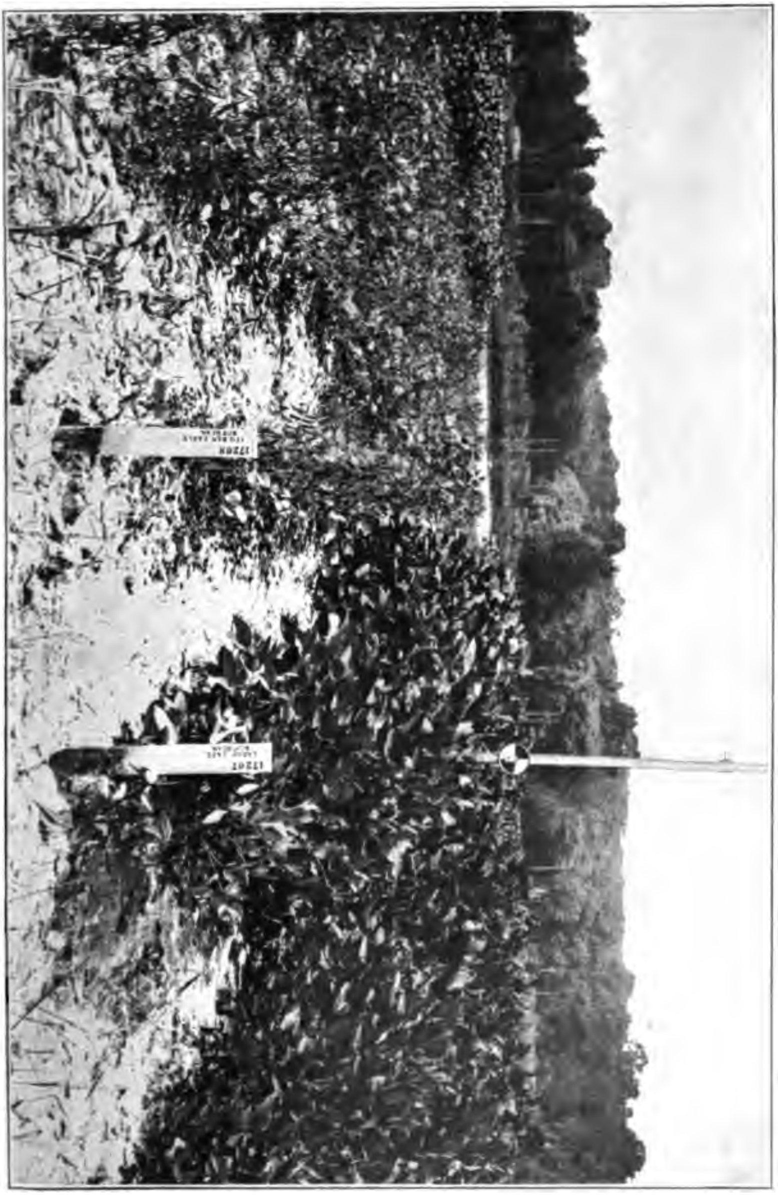
PLATE VI. Pods of soy beans, showing range in size and shape. Most of the varieties have three seeds to the pod, two and four being only occasional numbers. (Natural size.)

PLATE VII. Soy-bean pods; No. 19985 L, hairy and smooth pods from one heterozygote individual; No. 18258 C and No. 17278, smooth pods from heterozygote plants; No. 22898 A, a variety with tumid pods; No. 19186 B, a variety with much-compressed pods.

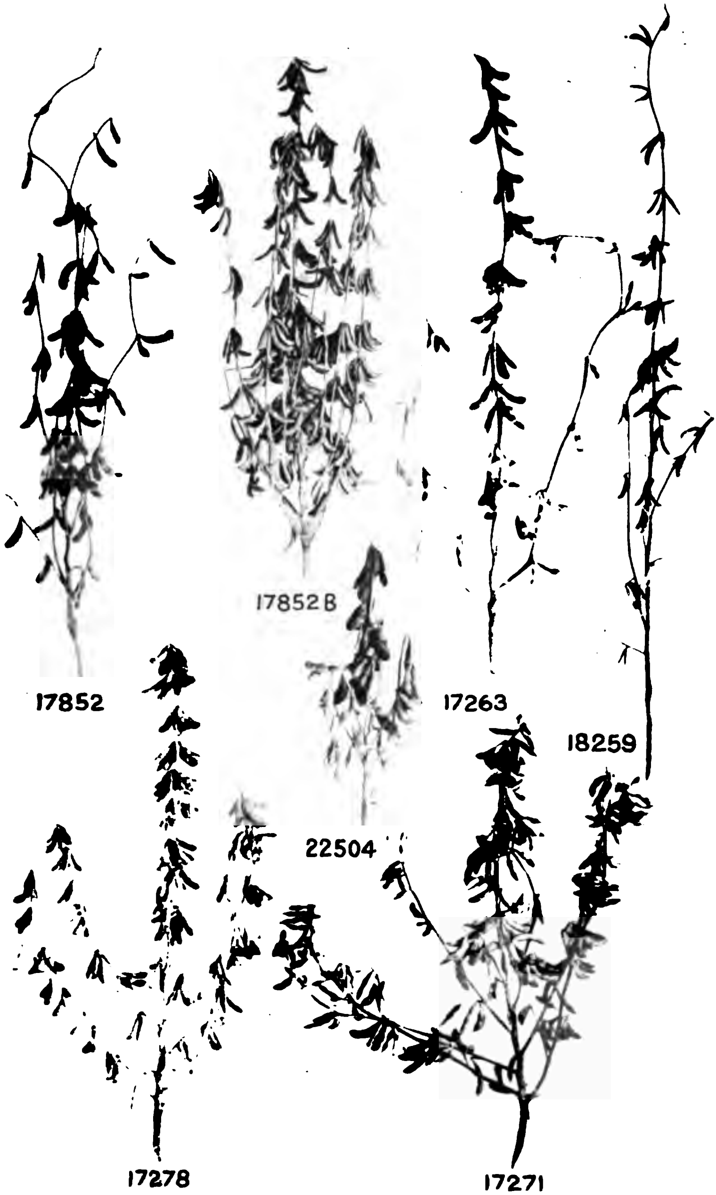
PLATE VIII. The seeds shown on this plate are as follows, beginning with the upper row and extending from left to right, there being two seeds of each variety: Row 1, Nos. 22882, 17278, 23297 B, 24674, 24641; row 2, Nos. 17251, 24180, 17252, 25656, 22899 A; row 3, Nos. 25118, 23546, 17255, 24685, 16790 B, 25138; row 4, Nos. 25136, 23229, 20406 G, 22644 A, 19186 D; row 5, Nos. 20412, 22333, 17256, 20409, 22411 A, row 6, Nos. 24182, 17252 B, 17857, 17271 L, 17260; row 7, 21079 L, 23299, 20407, 17852, 20797 A; row 8, 19985 L, 21079 M, 18258 C, 19982 A, 19982 A.

FIG. 1.—PLANTS OF A WILD SOY BEAN FROM SOOCHOW, CHINA, NO. 25138, GROWN AT THE ARLINGTON EXPERIMENTAL FARM, 1908.

FIG. 2.—PLANTS OF A SOY BEAN FROM CAWNPORE, INDIA, NO. 24689.

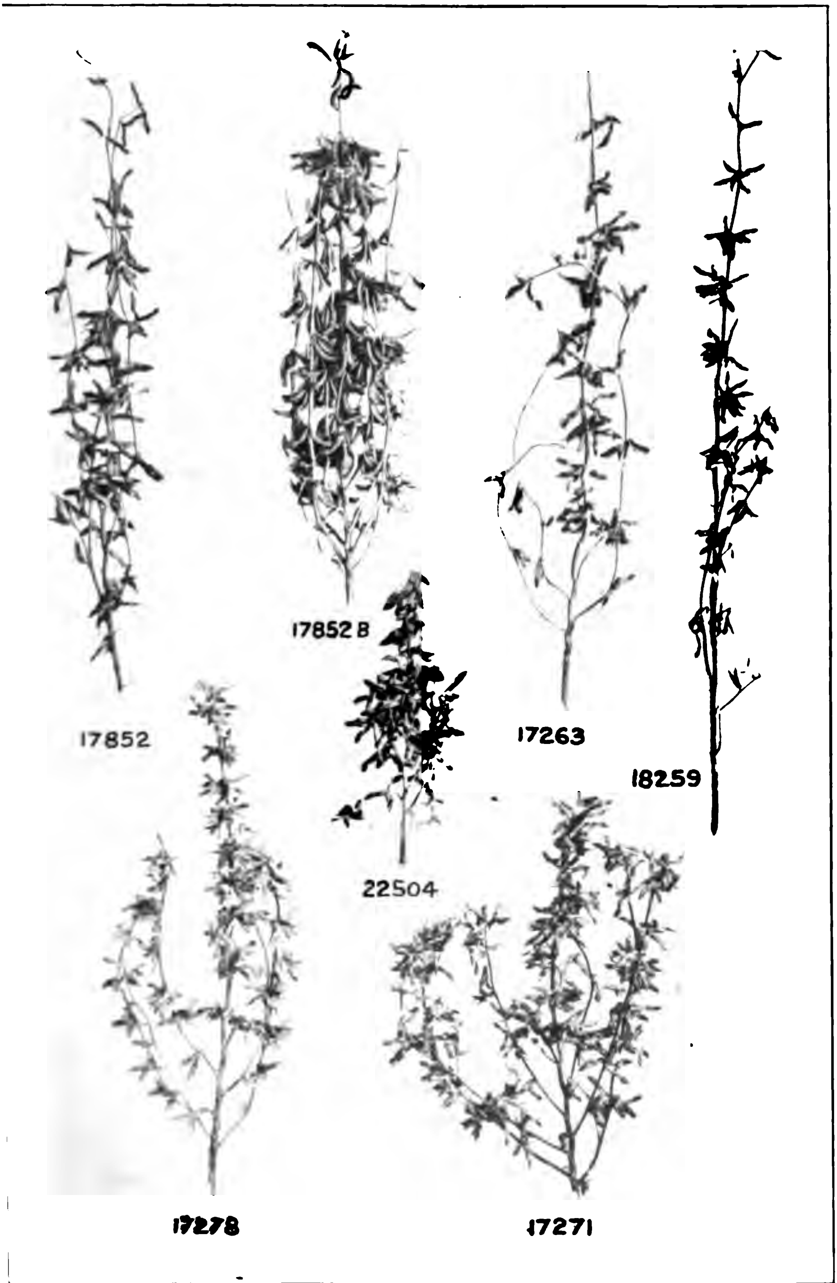


ROWS OF SOY BEANS GROWN IN THE VARIETY TESTS AT THE ARLINGTON EXPERIMENTAL FARM.



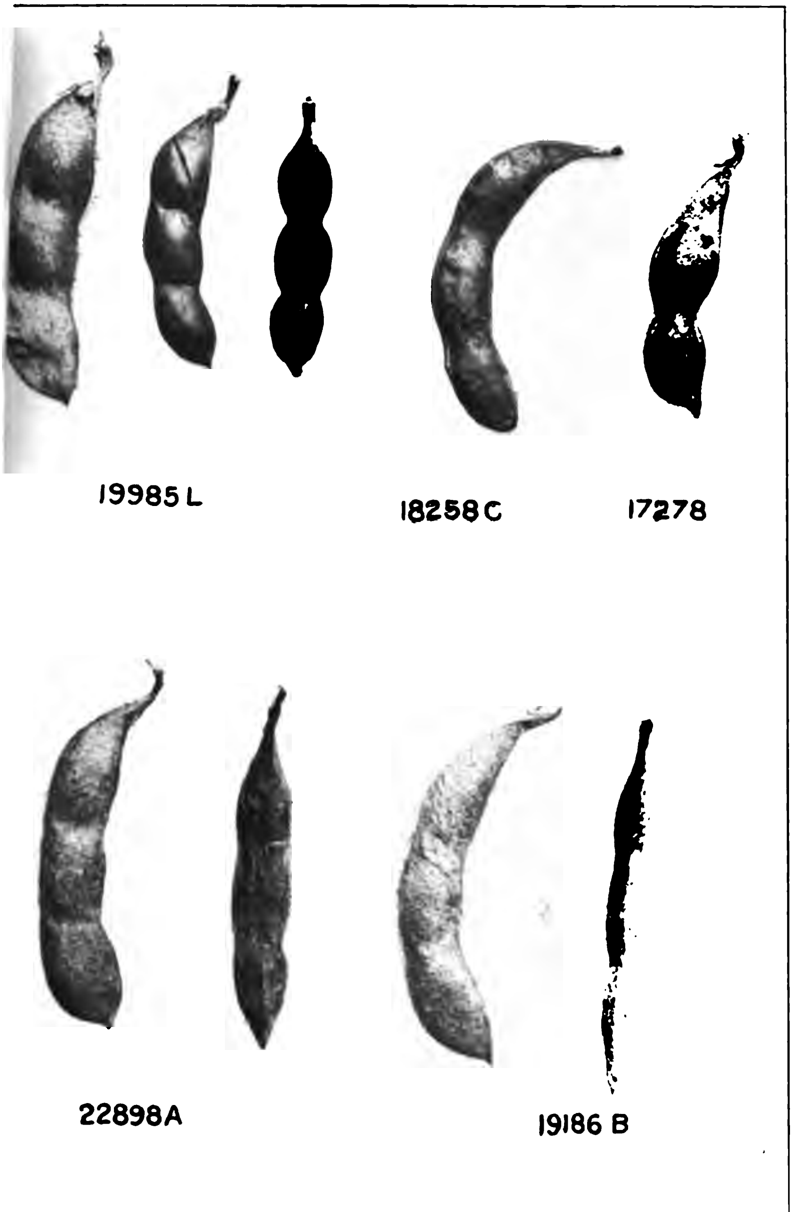
PLANTS OF SEVEN VARIETIES OF SOY BEANS, SHOWING TYPES OF HABIT.

No. 17852, Meyer; No. 17852 B, Peking; No. 17263, Austin; No. 18259, Pingsu; No. 22504, unnamed; No. 17278, Hollybrook; No. 17271, Haberlandt.



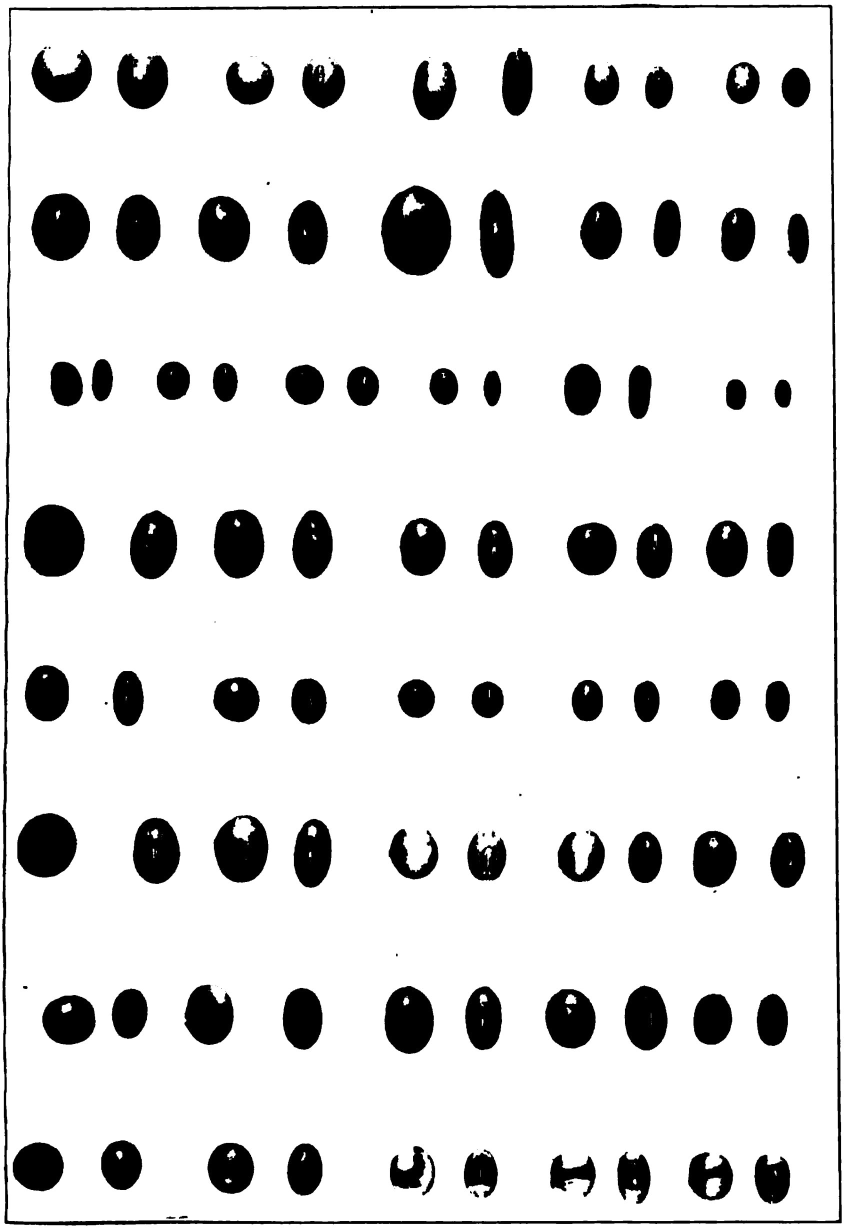
THE SAME PLANTS SHOWN IN PLATE IV AFTER HANGING IN A DRY ROOM FOR SIX MONTHS.

All have shattered badly but No. 17852 B, Peking.



PODS OF SOY BEANS.

No. 19985 L, hairy and smooth pods from one heterozygote individual; No. 18258 C and No. 17278, smooth pods from heterozygote plants; No. 22898 A, a variety with tumid pods; No. 19186 B, a variety with much-compressed pods.



SEEDS OF 36 VARIETIES OF SOY BEANS, SHOWING VARIATION IN SIZE AND FORM.

The bottom row shows peculiar types of coloration that occur only on heterozygote plants.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF PLANT INDUSTRY,

B. T. GALLOWAY, *Chief of Bureau.*

BULLETINS OF THE BUREAU OF PLANT INDUSTRY NOS. 198 TO 205, INCLUSIVE, 1910-11.

VOLUME XXVI.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 198.

B. T. GALLOWAY, *Chief of Bureau.*

DIMORPHIC BRANCHES IN TROPICAL CROP PLANTS:

COTTON, COFFEE, CACAO, THE CENTRAL AMERICAN RUBBER TREE, AND THE BANANA.

BY

O. F. COOK.

ISSUED JANUARY 14, 1911.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

BUREAU OF PLANT INDUSTRY.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., August 2, 1910.

Sir: I have the honor to transmit herewith a paper entitled "Dimorphic Branches in Tropical Crop Plants: Cotton, Coffee, Cacao, the Central American Rubber Tree, and the Banana," by Mr. O. F. Cook, Bionomist of this Bureau, and to recommend its publication as Bulletin No. 198 of the Bureau series. The paper shows that each plant produces two different kinds of branches, and points out numerous agricultural applications of these specialized habits of growth.

Respectfully,

G. H. Powell,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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DIMORPHIC BRANCHES IN TROPICAL CROP PLANTS: COTTON, COFFEE, CACAO, THE CENTRAL AMERICAN RUBBER TREE, AND THE BANANA.

INTRODUCTION.

It has been known for a long time that some species of plants have two or more forms of branches, but such specializations have been looked upon as botanical curiosities rather than as having practical significance in agriculture. Several of the most important economic species of the Tropics have now been found to have two or more different and distinct kinds of branches regularly present on every normal plant. These differences in the formation of the branches are worthy of scientific study and have definite relations to agricultural problems.

The specializations of the branches of the tropical crop plants are not mere inequalities of position and development like those that commonly appear among the trees and shrubs of the temperate regions. The differences do not arise merely from favorable or unfavorable positions on the plant that might affect the supply of food or the exposure to sunlight. The two kinds of branches are in most cases so definitely different that they do not replace or serve as substitutes for each other. The differences of the branches have sometimes been recognized by individual planters of coffee or cacao, but they have not received the study that the facts would warrant, either in their scientific aspects or in relation to practical agricultural applications.

As the best means of describing the nature and extent of the diversity of branches which exists in several of the more important tropical crop plants, it seems desirable to bring together in one report the facts of this kind which have been observed. The cultural significance of some of them is at once obvious and will show the desirability of further study in this class of phenomena. That much more information of this kind remains to be discovered seems strongly to be indicated by the fact that a definite diversity of branches has been found in all of the principal tropical crop plants to which attention has been directed with this idea in mind.

STRUCTURAL SIGNIFICANCE OF DIMORPHIC BRANCHES.

In attempting to understand the dimorphism of branches it is desirable to consider the nature of the structural units that compose the bodies of the plants. For some of the purposes of scientific study the individual cells or the tissues formed by the cells of one kind can be considered as units of structure. But many forms of plant and animal life also show structural units of a higher degree, such as the many similar joints or segments that compose the bodies of the worms and centipedes and the internodes of higher plants. Each joint is highly complex in itself, with a complete system of tissues and organs. The word "metamer" is used as a general term to apply to these complex units of organic structure. In some of the lower forms of animal life each metamer is capable of an independent existence, just as in some plants each joint of the stem or the rootstock, if planted as a cutting, will grow into a new individual. In a similar way each seedling represents a single metamer, able to produce others.

Two general groups of metamers may be recognized in plants—those that build up the vegetative parts of the plant and those that take part in the formation of the flowers and fruit. A vegetative metamer consists of a joint or section of the stem, together with a root or roots, and one or more leaves, as well as the hairs, scales, and other smaller appendages that belong to the joint, the root, or the leaf.

The floral or reproductive metamers of plants are generally smaller than the vegetative metamers. The part that corresponds to the joint or section of the stem of a vegetative internode is extremely short, while the part that corresponds to the leaf takes the form of a sepal, stamen, or pistil.

A plant as a whole represents a collective individual—a social organization, as it were—of the different kinds of subordinate metameric individuals, some devoted to vegetative purposes and some to reproduction. Botanical writers have often referred to the floral organs as transformed leaves, but it is quite as reasonable to suppose that the leaves represent floral or reproductive organs that have assumed vegetative functions.[a]

The stamens and pistils of the primitive types of plants are more nearly like those of the advanced types than are the vegetative metamers, showing that evolution has tended more toward the specialization of the vegetative parts. Dimorphic branches represent a somewhat advanced stage of vegetative specialization. A plant with

[a] Cook, O. F. Origin and Evolution of Angiosperms through Apospory. Proceedings, Washington Academy of Sciences, vol. 9, 1907, pp. 150–178

dimorphic branches has two kinds of vegetative metamers, in addition to the various kinds of floral or reproductive metamers. In the cotton plant, for example, seven principal kinds of metamers might be enumerated: The two kinds that compose the two types of branches, the two kinds whose specialized leaves form the involucre and the calyx, and the metamers of the corolla, the stamens, and the pistils. Some plants, such as Broussonetia, have two kinds of vegetative metamers alternating in the same stem, each alternate internode having only a small leaf.[a]

The diversity of the metamers does not end with the recognition of the different types, for the individual metamers of the various groups are often as distinctly different among themselves as the plants they compose, or even more so. If it be considered that a plant is an aggregate or colony of metamers, it follows that causes of differences between plants are to be sought in the structure or behavior of the component metamers. Plants with dimorphic branches not only have two kinds of vegetative metamers, but have them arranged in separate series. The variations of the higher plants are much more readily appreciable than the variations of the higher animals, because the same character is repeated in the large number of internode individuals that compose the bodies of plants.

The individuality of the internodes and the significance of this fact in the developmental history of plants were appreciated over a century ago by Goethe, the great German naturalist and poet. In his poem on "The Evolution of Plants," the series of changes in the forms of the metamers is traced from the seedling, the process of plant growth being used as an illustration of the general idea of evolution from simple forms of life to more complex.

> Yet it appears very simple, when first we can see the new structure,
> This in the world of the plants is ever the state of the child.
> Growth is continued at once, one shoot coming forth from another,
> Nodes upon nodes towering up, all repeating the form of the first.
> Still they are not quite the same; in manifold ways they are varied,
> Each of the leaves, as you see, develops beyond the preceding,
> Larger, and sharper in margin, as well as more deeply divided.

Not only the differences of the vegetative internodes, but those of the internodes that are modified as flower stalks and floral organs were recognized, as well as the sexual differentiation of the stamens and pistils, though the poem was published in 1790, three years before the announcement of Sprengel's discovery of the fertilization of flowers. Comparison of the series of gradually modified internodes

[a] Other examples of anisophylly have been described by several botanical writers. See Wiesner, J., Studien ueber die Anisophyllie tropischer Gewaechse, Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe, Kaiserliche Akademie der Wissenschaften, Vienna, vol. 103, 1894, p. 625.

in the individual plant with the successive links of the chain of organic development led Goethe to the view that each plant is an evidence of a general law of evolution.

> Every plant will declare it, the law of the endless creation,
> Every flower will repeat it, louder and louder the voice.

SIMILARITY OF DIMORPHIC BRANCHES TO ALTERNATING GENERATIONS.

Darwin also recognized the individuality of the internodes of plants, though apparently without attaching an evolutionary significance to the fact, no reference being made to it in "The Origin of Species." Attention has been called by Mr. Argyle McLachlan to an interesting paragraph in another work, in which Darwin draws a comparison between the leaf buds of plants and the individual animals that build up the branching colonies of zoophytes:

> The examination of these compound animals was always very interesting to me. What can be more remarkable than to see a plant-like body producing an egg, capable of swimming about and of choosing a proper place to adhere to, which then sprouts into branches, each crowded with innumerable distinct animals, often of complicated organizations. The branches, moreover, as we have just seen, sometimes possess organs capable of movement and independent of the polypi. Surprising as this union of separate individuals in a common stock must always appear, every tree displays the same fact, for buds must be considered as individual plants. It is, however, natural to consider a polypus, furnished with a mouth, intestines, and other organs, as a distinct individual, whereas the individuality of a leaf bud is not easily realized; so that the union of separate individuals in a common body is more striking in a coralline than in a tree. Our conception of a compound animal, where in some respects the individuality of each is not completed, may be aided by reflecting on the production of two distinct creatures, by bisecting a single one with a knife, or where nature herself performs the task of bisection. We may consider the polypi in a zoophyte, or the buds in a tree, as cases where the division of the individual has not been completely effected. Certainly in the case of trees, and judging from analogy in that of corallines, the individuals propagated by buds seem more intimately related to each other than eggs or seeds are to their parents. It seems now pretty well established that plants propagated by buds all partake of a common duration of life, and it is familiar to every one what singular and numerous peculiarities are transmitted with certainty by buds, layers, and grafts, which by seminal propagation never or only casually reappear.[a]

It is plain from this passage that Darwin considered the internodal structure of plants as a method of vegetative propagation of new individuals rather than as an example of successive stages of evolutionary progress. This becomes the more evident from his comparison of the results of vegetative propagation with those obtained by sexual reproduction. The general tendency to uniformity among vegetative individuals lends greater significance to differences that

[a] Darwin, Charles. Journal of Researches, end of chapter 9.

regularly appear among vegetative internodes of the same plant. Dimorphic branches and similar specializations show that change of characters in vegetative internodes is a definite phenomenon in the development of plants, like changes that take place during the development of many animals. Much evolutionary importance has been attached by zoologists to the recapitulation of ancestral characters in embryos, as well as to metamorphosis and alternation of generations. All of these phenomena find their parallels among plants, though botanists have given them relatively little attention.

The evolutionary development of the various degrees of specialization of the branches of such a plant as the cotton becomes more comprehensible if we compare it with the stages through which a simple herb would naturally pass in attaining the stature and habit of a branching shrub or tree. Many small herbs bear single terminal flowers, but in plants that have increased in size and complexity terminal flowers are replaced by axillary flowers or flower clusters, and these tend in turn to grow out into branches, able to subdivide still further and bear larger and larger numbers of flowers.

In the cotton plant the primary branches have now become as sterile as the main stem, and the extra-axillary branches that normally bear the fruit also have the power of changing over into sterile limbs, the production of fruit being deferred to a later generation of branches to enable the plant to construct a larger vegetative framework.

The main stem and the one or more series of vegetative branches which intervene between the germination of the seed and the formation of another flower correspond to several generations of the vegetative parts of a simple herb and might also be compared to the vegetative generations of the plant lice and other lower animals that are able to propagate for several generations by simple vegetative subdivision, instead of requiring sexual reproduction for each generation of new individuals, as among the higher animals. The relations between the sterile and the fertile branches of cotton and of other plants that have dimorphic branches afford a rather close parallel to the original examples of the phenomenon of alternation of generations, though they are not comparable to the changes that occur in the life histories of the liverworts, mosses, and ferns which botanical text-books commonly describe as alternation of generations.[a]

A shrub or tree may be thought of as a colony or complex of many individual branches each corresponding to a separate plant in a species of smaller shrubs or herbs. Dimorphism of branches means that there are two kinds of these branch individuals that follow each

[a] Cook, O. F., and Swingle, W. T. Evolution of Cellular Structures. Bulletin 81, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1905.

other in definitely alternating sequences. The seeds of the cotton, coffee, and many other species do not grow at first into plants similar to the branches which produced the seeds. The seedlings at first develop upright sterile stems and a series of vegetative branches. Another type of branches is formed for the production of flowers and fruit, and then there may be no return to the condition of the upright main stem and the purely vegetative limbs except by way of the seed and seedlings.

In some plants the formation of different kinds of vegetative inte nodes is more specialized in relation to time, the whole plant goin over from one habit of growth or form of foliage to another. In th eucalyptus and in many coniferous trees related to the juniper the is a juvenile form of foliage altogether different from that of th adult trees. This phenomenon is not to be confused with the simple dimorphism of branches shown in the tropical crop plants, thou some of the Coniferæ have this as well as the other. Cuttings lateral branches, not being able to replace the main axis, do not r produce the form of the parent tree. Some of the Coniferæ pr duce a juvenile type of foliage only in exceptional cases of bud r version, which may even be confined to buds forced from the ax of the cotyledons, as explained by Beissner and Beyerinck.[a]

DIFFERENT TYPES OF DIMORPHIC BRANCHES.

It is easier to describe and compare the dimorphic forms branches in the several species of cultivated plants if we consider advance a general difference of function. Some branches have t same form and functions as the axis or main stem of the plant, whi others are more or less restricted to the bearing of fruit or to oth special purposes. The specializations of the branches show vario directions and degrees in different species and varieties of plants, b in each case it is possible to distinguish between branches that a more similar to the main trunk and those that are less similar.

In the present report the word "limb" is used as the general na for branches that are unspecialized or that are specialized for ve tative functions instead of for fruiting. The limbs continue t growth and share the functions of the trunk or main stem of t plant.[b] Limbs may have vegetative functions only and may

[a] Beissner, L. Ueber Jugendformen von Pflanzen, speciell von Coniferen. Beri über die Verhandlungen der deutschen botanischen Gesellschaft, vol. 6, 18 p. lxxxiii. Beyerinck, M. W. Beissner's Untersuchungen ueber der Reti porafrage, Botanische Zeitung, vol. 48, 1890, p. 518.

[b] In the diagrams that illustrate the habits of branching in this report vegetative limbs are drawn in solid lines like the main stem, while the fruit branches are indicated by broken lines. (See figs. 1-7.)

ble to bear flowers or fruit. Branches that bear fruit may be espondingly restricted on the vegetative side. Different species varieties of plants are so unlike that no general principle of sification can be applied except that of distinguishing between different forms of specialization.

he most useful distinction between limbs and other forms of aches relates to differences of function rather than to the structure positions of the parts. In the cotton plant, for example, the llary branches function as limbs, while in the Central American ber tree they are definitely specialized for fruiting and do not ome permanent parts of the tree. They die and drop off after y have borne two or three crops of fruit.

he branches that arise from extra-axillary buds also have their ctions reversed in the two cases. In the rubber tree the extra-llary buds produce limbs but no fruiting branches, while in the ton plant all the fertile branches arise from extra-axillary buds.

DIMORPHIC BRANCHES OF THE COTTON PLANT.

Though the dimorphism of the branches of the cotton plant is not extreme case, it may be better to use it as the first example before sidering the other tropical plants that are less known in the United tes. The differences are more striking in some of the tropical nts, but are no more significant in their agricultural bearings. e distinctions between the two kinds of branches of the cotton nt depend upon position and function rather than upon any very picuous differences of form or structure. This may explain why dimorphism of the branches has continued to be overlooked in so iliar a plant as the cotton, although the difference between ordi-y short fruiting branches and large basal branches or "wood bs" is obvious at a glance and is familiar to all planters.[a]

he cotton plant, as represented by the Upland varieties in general ivation in the Southern States, consists of a central axis or lk" bearing a leaf at the end of each joint or internode. nches that arise from the axils of the leaves do not normally r fruit, but behave like divisions of the main stalk. A fertile ch arises at one side, right or left, of an axillary branch or an veloped axillary bud which may give rise to an axillary branch in the season. The position is usually constant throughout in ame stalk, so that the plants can be distinguished as right-handed

[a] For a brief statement regarding dimorphism of branches in cotton, see "Wee-Resisting Adaptations of the Cotton Plant," Bulletin 88, Bureau of Plant stry, U. S. Dept. of Agriculture, 1906, pp. 19–20. See also "A Study of sity in Egyptian Cotton," Bulletin 156, Bureau of Plant Industry, U. S. t. of Agriculture, 1909, pp. 28–30.

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or left-handed with reference to the position in which their fruiting branches are borne along the main stalk.

On the fruiting branches this regularity in the position of the flowers is not so obvious, for the joints are twisted to bring all the leaves to the sides and all the flower buds on top. The flower buds appear between the bases of the stipules, sometimes nearer the right-hand stipule, sometimes nearer the left. The stipule that is close to the base of the flower stalk is usually larger than the other.

Antidromy, as the condition of right and left handedness of plants has been called, consists in the fact that the stems of the different individual plants reverse the direction of the spirals in which the leaves and branches are arranged. On some cotton plants the extra-axillary branches occur on the right side of the axillary branches; in other individuals on the left side. If a stalk on which the extra-axillary buds appear to the right of the axillary buds be considered right-handed, the turn of the spiral will pass to the right in going by the shortest route from any given branch to the one above. Thus it appears that the extra-axillary bud is always above the axillary, in the sense that it is farther up the spiral.

In all the different species and varieties of cotton thus far examined right-handed and left-handed stalks seem to be about equally numerous. As the Guatemalan types in which the branch dimorphism was first studied had never undergone close selection, the question was raised whether among the carefully bred American varieties there might not be specializations toward one direction of the spiral. No indication of this was found in a large series of varieties studied by Mr. F. J. Tyler at Waco, Tex. Seeds from the same boll were also found to give about equal proportions of right-handed and left-handed seedlings. The possibility remained that the direction of the spiral may be determined in advance by the positions in which the seeds develop on the placenta. To test this theory seeds from two rows of the placenta were planted separately, but gave right and left handed plants without reference to the position on the placenta. The manner in which this diversity arises remains unexplained.

The axillary buds have been found in all the types and varieties of cotton thus far observed, but they are often very small and dormant. They may all remain undeveloped unless the plant is cut back or severely checked by unfavorable conditions. In many kinds of cotton both types of branches are commonly to be found on the same plant.

The difference between the two kinds of branches was first appreciated in Guatemala in connection with the indigenous Kekchi cotton. The lower joints of the main stem of the Kekchi cotton usually produce two branches, one a fertile branch with flowers and fruit, the

ther a sterile limb with leaves only. It was noticed also that the ranches that bear the flowers arise in the same position as the flowers hemselves—not in the axils of the leaves, but at the side of the xillary bud.

The axillary branches of cotton function normally as equivalents f the main stem in the sense that they do not bear any flowers or ruits except in the indirect way of producing other branches of the ertile sort from extra-axillary buds. Fertile branches borne by the nain stem of a cotton plant may be called primary fruiting branches; hose that come from limbs may be called secondary fruiting ranches. Normal fruiting branches of both kinds bear a flower bud t each node. Secondary limbs may be produced from primary imbs, or even from axillary buds of the fruiting branches, especially f a plant has been injured or pruned or suddenly forced into renewed rowth late in the season. Only in rare and abnormal cases is a flower orne directly on a branch that arises from an axillary bud.

It is the normal habit of some varieties to develop vegetative limbs rom axillary buds along with the fruiting branches that come from he extra-axillary buds, as in the Kekchi cotton of Guatemala. Some arieties do not have true axillary branches, but develop limbs from he extra-axillary buds of the main stem, the production of flowers eing deferred until fertile branches can be produced on the limbs. This is sometimes the case with the Pachon cotton of western Guatemala and with the Rabinal cotton of the central plateau region. In n experiment with the Pachon cotton at Lanham, Md., no axillary imbs were produced, each node bearing only an extra-axillary limb. n another experiment at Trece Aguas, Alta Vera Paz, Guatemala, he Pachon cotton showed nearly the normal habit of the Upland ype of cotton, bearing most of its crop directly on fertile primary ranches, sending out small primary limbs only in the latter part of he season.

In the Old World cottons (*Gossypium herbaceum*) and the Sea Island cottons it is not usual for the plants to develop true axillary imbs to functional size. If the other branches are injured or stunted, he axillary limbs may push out a few leaves.

In the Egyptian cotton, also, there is a very general tendency to levelop vegetative limbs as well as the fertile branches from extra-axillary buds. The axillary buds usually remain dormant unless in injury or other abnormal condition forces them into growth. At the base of the main stalk it is often difficult to see that the limbs come from extra-axillary buds, but a little farther up it becomes obvious that both the limbs and the fruiting branches have extra-axillary positions on the same side of the axillary bud, with much regularity. Finally, some varieties of Upland cotton may not form

any vegetative branches, though extra-axillary limbs and even axillary limbs may be formed by the same varieties when grown under conditions that favor a large development of the vegetative parts.

In the so-called "cluster" cottons it often happens that one or more buds, or bolls, appear to be borne on short axillary branches, but careful examination will usually show that the fruit does not come directly from the axillary branch itself, but belongs to a very short fertile branch arising from the axillary. In the Egyptian cotton a short fertile branch is often pushed out from one side of the dormant bud that represents an undeveloped axillary branch. Sometimes the bud that represents an undeveloped axillary branch is carried up a little on the base of the extra-axillary branch. After this has occurred, a branch that arises from the axillary bud appears to be borne by the extra-axillary branch rather than by the main stem of the plant. This impression may be strengthened still further if the axillary bud or the fruiting branch to which it sometimes gives rise be changed into flower bud, as in the cluster cottons that show an abnormal propensity toward fruit production. Sometimes the normal extra-axillary fruiting branch is also replaced by a single flower bud, so that three flower buds may appear to come from each of the nodes of the main stem instead of the more normal complement of a limb and a fertile branch.

In varieties of cotton that are not inclined to produce true axillary limbs, the extra-axillary branches usually assume the functions of limbs; that is, they produce flowering branches instead of bearing the flowers themselves. A true axillary limb seldom stands alone on the main stem, but is almost invariably accompanied or preceded by a fertile branch. The insertion of a limb and a branch close together, at the same node, makes it easy to ascertain whether true primary limbs are present or limbs that represent fruiting branches transformed for vegetative purposes.

The leaves of the vegetative limbs and those of the main stem are larger and have relatively longer petioles than those of the fruiting branches. Another definite difference between the leaves of the main stem and those of the fertile branches has been noticed by Mr. Rowland M. Meade in the Triumph variety of Upland cotton. The leaves of the main stem have nectaries on three of the veins, while those of the fertile branches have only the one nectary, on the back of the midrib. When the fruiting branches are shortened, as often happens in the Egyptian cotton, the petioles of their leaves are also greatly reduced in length, a step toward the still more distinctly abnormal condition where the leaves of the shortened fertile branches begin to show some of the characteristics of the involucral bracts.

In types of cotton that have a normal development of branches an axillary bud yields only a sterile vegetative branch or limb. From extra-axillary buds three things may come: (1) Flowers, (2) fertile branches bearing a series of flower buds, one at each node, and (3) extra-axillary limbs having the position of fertile branches but sharing the form and function of the axillary limbs.

VARIOUS FORMS OF FRUITING BRANCHES.

As the fruiting branches represent a specialized feature of the cotton plant, it is not surprising that different stages of specialization are found in the fruiting branches of the various species and varieties of cotton. Though the general distinctions between the vegetative limbs and the fertile branches apply to all forms of cotton thus far examined, definite differences often appear between the fruiting branches of different varieties and even among the individual members of the same variety; and since these differences in the methods of producing the fruit are of direct agricultural importance, it is worth while to understand them in detail.

In a general botanical sense it might be said that the fruiting branches of all kinds are intermediate between the vegetative limbs and the flowers, for botanists consider that each flower of a plant represents a shortened branch. The range of specialization of fertile branches lies, therefore, between the limb and the flower. The fertile branches of some cottons are long and leafy, much like the vegetative limbs, while in others they may be so much shortened as to appear merely a part of the flower stalk. In the great majority of cases the fertile branches are definitely unlike either of the extremes, but the range of forms is completely covered if the whole series is considered.

A comparison of the branches of the Egyptian cotton with those of the Kekchi cotton or with our United States Upland varieties may serve as an illustration of the different degrees of specialization found in the branches in different types of cotton. In the Egyptian cotton the basal joints of the fruiting branches are longer than in the Upland, while on the vegetative branches the basal joints are shorter than on the corresponding branches of the Upland. In other words, the differences between the basal joints of the two kinds of branches are much greater in the Egyptian cotton than in the Upland series. The tendency for the basal joint of the fruiting branches to be longer than the others is very general, and likewise for the basal joints of vegetative branches to be shorter, but in the Egyptian cotton the contrast is more accentuated than usual.

The Hindi cotton that figures in literature as a contamination o the high-grade Egyptian stocks shows the slightest differentiatio of the fruiting branches. These branches have a curious zigzag forn that readily distinguishes them from the straight vegetative limbs, bu they may retain the nearly upright position of the limbs and do no appear to have lost any of the vegetative functions. In such case the flower buds are usually aborted at an early stage, though matur bolls are sometimes found on branches that remain more uprigh and limblike than those in Upland or Egyptian varieties.

The other extremes of differentiation in the direction of the shorten ing of the fruiting branches are found in great variety among th so-called "cluster" cottons. The simplest form of clustering is rep resented by a mere shortening of the joints of the fruiting branche which brings the flowers and bolls closer together than in norma long-branched varieties. More pronounced clustering leads to dense groupings of bolls by the development of additional flowers on shor branches from the axils of the leaves of the fruiting branches. In it most extreme form the clustering has the effect of reducing the num ber of bolls. The leaf buds that normally continue the growth of th branches are sometimes replaced by flower buds, or adjacent lea buds may be aborted and fall off, so that the branch soon ends witl a flower or a boll and no more joints can be added.

It usually appears that the cluster habit is merely a form of spe cialization of the fruiting branches, for the vegetative limbs an axillary branches are usually not affected at all by the cluster ten dency. In other cases the axillary buds of the vegetative branche as well as the terminal buds, may appear to be replaced by flowe buds, though it is usually found, on closer examination, that th flower bud is borne on a short fertile branch that rises from an other wise abortive axillary branch.

Finally, it sometimes happens, as in the Triumph variety of Uplan cotton, that two forms of fruiting branches are regularly produced The normal condition with the Triumph cotton is to have several of the lower fruiting branches very short and determinate, so that some times this variety is erroneously described as a cluster type.

STERILITY OF INTERMEDIATE FORMS OF BRANCHES.

Botanists are familiar with the fact that changes and substitution of form often occur among the floral organs of plants. The most familiar change of this kind is in the so-called doubling of flowers meaning the addition of a larger number of petals to the corolla. In many cases the number of stamens decreases as the petals become more numerous, and many double flowers are completely sterile, both the stamens and pistils being transformed into petal-like organs.

Such changes are occasionally found in the flowers of the cotton plant, as when additional petals are inserted on the staminal tube. Sometimes these additional petals are very small, as though individual stamens had been changed into petals. More serious modifications appear when petals of nearly normal size are inserted on the base of the staminal tube, which is then subdivided into five separate columns alternating with the supernumerary petals. Pistils are sometimes transformed into supernumerary petals, though the change is seldom complete. Some of the pistils usually remain unmodified, but the boll is deformed and seldom develops to maturity.

In view of the occurrence of intermediate conditions between the parts that are so profoundly different as the stamens and pistils, it would naturally be expected that intermediate stages would also occur between the two forms of branches, in spite of the fact that dimorphism represents the normal condition. Intermediate forms of branches do occur, and, like the intermediate forms of the floral organs, they are usually sterile. Not only do most of their flower buds abort, but the branches themselves commonly fail to reach full development. They often wither and fall off after producing one or two internodes.

If such branches occurred without regularity on the plant, it might be difficult to determine the nature of the abnormality, but they have evident relations to particular varieties and to definite positions on the plants. In following the branching habits of the Egyptian cotton through the season of 1909, Mr. McLachlan noticed the curious fact that an interval of rudimentary or abortive branches usually occurs on the main stem of the plant, consisting of two or three internodes above the last of the sterile vegetative branches and below the first normally developed fruiting branch. Even on large plants that bear limbs 4 feet or more in length, with 30 internodes and upward, and fruiting branches nearly 2 feet in length, composed of twelve internodes, the intervening nodes are either quite vacant or have branches only a few inches long, usually with only one internode, very seldom with more than two or three. Sometimes there is a more gradual transition from these small branches to those of normal length, but there is a strong tendency to abortion of the flower buds on all of the shortened lower branches of the fertile form.

As already suggested, the frequency of abnormal branches in the Egyptian cotton may be connected with the contamination of the Egyptian stocks with the so-called Hindi cotton, a type related in some respects to our United States Upland cotton, but widely differing in others. Though the Hindi cotton has the two distinct forms of branches, they appear less different than in any other variety included in the experiment. It seems to be the regular habit of Hindi

cotton to shed a large proportion of its flowers in the very young stages and then to develop the vegetative functions of these barren fertile branches which not only grow to large size, but often produce branches of their own from axillary buds. In view of these habits of the Hindi cotton, it does not appear improbable that the frequent tendency of the Egyptian plants toward abnormal, intermediate forms of branches is caused, or at least intensified, by admixture with the Hindi type. In any case the characters of the branches must be taken into account as one of the standards of selection in the Egyptian cotton, as well as in Upland varieties.

In addition to the relatively small and late development of the fruiting branches on vigorous, overgrown Egyptian plants a very large proportion of the flower buds are aborted and fall off. Many of them are dropped while still very small and even microscopic in size. This abortion of the buds appears to have a definite relation to the habits of branching of the plants. If the fruiting branches are of a normal, slender, and horizontal form, the chances of the buds being retained are very much greater. If, on the other hand, the fruiting branches become more robust and take an oblique or upright direction and thus resemble the vegetative branches or limbs, the buds almost invariable fall off while still very young. Only the scars of the fallen buds may remain as a distinction between the fertile and sterile branches, as in the Hindi cotton. On different plants and even on different branches of the same plant, the buds attain different sizes before they abort and fall off, and these different sizes of the buds may be considered as marking intermediate stages between the normal fertile branches which retain their fruit and the normally sterile vegetative branches which produce no trace of flowering buds.

The practical point is that these intermediate conditions and forms of the branches, even when they bear large numbers of buds, produce very little fruit, often none at all. The failure of a plant to maintain the normal specialization of the two forms of branches is an undesirable character from the standpoint of acclimatization and breeding. There is not only a tendency on the part of the newly imported plants to increase the number of sterile vegetative branches at the expense of the fertile, but a tendency for the remainder of the fertile branches to become abnormal.

While it is possible for a very large and vigorous plant to produce a good crop of cotton with a sufficiently long season, there can be no regular assurance of large yields unless the plants begin to bear early in the season. The plants must begin to produce fertile branches early in the season and numerous buds on each branch. It is not to be expected that all of the buds of a fertile plant will set bolls, or that all the bolls will reach maturity, but this only makes it the more

important that the plants shall be able to produce enough flower buds to take advantage of all opportunities for the setting of a large crop. The tendency of the Egyptian cotton to grow larger vegetative branches and smaller fruiting branches than the Upland cotton is responsible for differences in yield and earliness between the two types.

In Egypt and in the cooler parts of the United States the Egyptian cotton produces small, early plants with much the same habit of growth as the Upland cotton. The more fertile soils and the greater heat of the spring months in the Southwestern States induce a much more luxuriant growth, especially in the Egyptian cotton. The plants not only shoot up to a very large size, but put forth many vegetative branches from the base of the stalk before any fertile branches are formed.

INTERMEDIATES BETWEEN FERTILE BRANCHES AND FLOWERS.

Farther toward the top of the plants another intermediate condition of the branches is frequently found, especially in the Egyptian cotton. The fertile branches become abnormal by approximation to flower buds. The leaf bud that would continue the growth of a normal fruiting branch either becomes abortive or appears to be directly transformed into a flower bud. A further evidence of the abnormality of these branches is found in the fact that their leaves are usually different from those of normal fruiting branches and tend to take on the form of the floral bracts. The first and most frequent manifestations of this tendency are found in the shortening of the petiole or stem of the leaf and the enlargement of the stipules—the small, pointed, leaf-like structures at the base of the petiole. (See Pl. I.)

On the normal fruiting branches the stipules are always shorter than those of the main stem or vegetative limbs, remaining narrow and pointed; but on the abnormal, shortened, fruiting branches one or both of the stipules become broadened and thickened as in the formation of the floral bracts. In Egyptian cotton it is easy to find all these abnormal fruiting branches completing a series of gradations between normal leaves or completely modified floral bracts. That the abnormality of the branches involves in this case the breaking down of the distinctions between the internodes of normal fruiting branches and those of the more specialized floral organs is also shown by the fact that leaf-like bracts are often found as well as bractlike leaves, and that supernumerary petals, divided staminal tubes, and abnormal pistils are of frequent occurrence on plants that show abnormal intermediate forms of branches.

Each of the three bracts that inclose the bud of the cotton plant represents a specialized leaf formed by enlarged stipules united with a greatly reduced blade. In Egyptian cotton it often happens that the leaf subtending a flower bud does not retain its normal size and shape, but becomes more or less intermediate between a leaf and a bract. One or both of the stipules may be enlarged and united with the blade, or the blade may remain separate, with the stalk more or less shortened.

The formation of these abnormal organs shows, as in the case of the branches, a failure to maintain the normal specialization of the parts. The processes of growth that should take place only in the bracts are partly anticipated in the formation of the leaf, the result being an intermediate expression of the leaf and bract characters. Plants that have the bractlike leaves are also likely to have leaflike bracts, more deeply divided at the apex than the normal bracts, and often deeply lobed or cleft nearly to the base.

The liability of the normal specializations to break down may be connected in a general way with the fact of dimorphism of the branches. The fertile branches can be looked upon as inflorescences that have approached the vegetative form and tend to revert to more determinate conditions. The dimorphism of the branches, in such plants as cotton and coffee, means that there are two kinds of vegetative internodes, one forming branches devoted to purely vegetative purposes, the other somewhat intermediate between vegetative and reproductive internodes. Individual internodes which are accessory to the reproductive internodes occur in many plants, just below the flowers. The fruiting forms of specialized branches are made up of such intermediate or slightly specialized internodes.

The practical significance of the abnormalities of the involucre is the same as in the case of the branches. The disturbance of the normal processes of growth are shown to have affected more than the mere external form of the plants. The flower buds that follow the abnormal bractlike leaves are almost invariably aborted, and if the number of such abnormalities is large the plant becomes unproductive or even completely sterile. Such abnormalities have been particularly abundant in the Dale variety of Egyptian cotton, both in 1908 and 1909, but the 1909 planting from seed raised in Arizona in 1908 shows a much larger proportion of normal individuals than among the plants grown from imported seed. Some of the plants of the Dale cotton have the strict upright form of the so-called limbless varieties of Upland cotton, and some produce no flower buds in the normal place on fruiting branches, but only from buds of short axillary branches that appear to represent transformed leaf buds, all other buds being completely aborted. Sometimes all of the buds abort and the whole plant remains completely sterile.

An apparent transformation of the axillary leaf bud into a flower bud is of frequent occurrence in some of the cluster varieties of Upland cotton, but is also common in Egyptian cotton, especially in the Dale variety that has the abnormal branches and bracts.

A transformation of leaf buds into fruiting buds might be expected to increase the fertility of the plants, but this is not the result in the Egyptian cotton for the reason that the most frequent effect of this transformation is to put an end to the growth of a fertile branch. A growing branch must have a leaf bud at the end, and if this terminal bud is transformed into a flower, the branch does not continue. If the transformation is successfully accomplished, we secure one additional boll, but at the expense of a fertile branch which might produce several bolls. The loss is still further increased by the fact that the plants addicted to this habit of transforming leaf buds into flower buds lose a very large proportion of their buds by abortion.

The frequency of abnormalities in the bracts and in the floral organs shows a general disturbance of the normal process of heredity in the newly imported varieties, such as frequently attends hybridization. In the Egyptian cotton varieties it does not appear that these phenomena are directly connected with hybridization, for they occur in large numbers of plants that give no evidence of admixture of Hindi or Upland characteristics. Nevertheless, the whole series of abnormalities may be considered from the standpoint of hybridization, in that they represent intermediate stages between organs of the plants that are normally distinct and different from each other. In each case there is a failure to follow the normal paths of development by which the normal individual advances from the characters of the seedling to those of the adult plant. Although a plant may have all of its characters normally developed in some of its parts, the parts that show the intermediate conditions of the characters may be quite as abnormal as in any hybrid, and resulting sterility is quite the same from the practical standpoint.

The study of the evolution of plant structures has led to the recognition of a phenomenon called translocation of characters, or homœosis, the carrying over into one part of the plant of a character that normally appears in another part, such as the manifestation of the bract characters by the next leaf below the bracts in Dale cotton.[a]

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[a] Leavitt, R. G. A Vegetative Mutant and the Principle of Homœosis in Plants. Botanical Gazette, January, 1909, p. 64.

"In homœosis a character or a system of organization which has been evolved in one part of the body is transferred ready-made to another part. The great mass of instances are of the class called teratological. By this designation we mean substantially that they are suddenly appearing deviations from the customary structures."

In extreme cases a single long-stemmed boll may arise from the axil of a leaf at the base of the fertile branch. This might be taken to indicate a direct transformation of the axillary bud into a fertile branch; but further examination will usually show, even on the same plant, great variation in the pedicels of these axillary bolls, making it evident that they are not simple pedicels, but shortened branches. Small bractlike leaves or stipules are occasionally present, even on straight stems, and sometimes the joint between the branch proper and the true stem or pedicel of the boll remains distinct, even when there are no leaves or stipules. (See Pl. II.)

Where the axillary branches are longer and more definitely jointed it becomes possible to see that the bolls are really borne on a short fertile branch that rises in turn from a short true axillary branch, instead of being inserted directly on the main stem. A shortened axillary branch may represent three normally independent elements, an axillary vegetative branch, a secondary fertile branch borne on the axillary, and the pedicel of the boll, all fused into a simple stem. In some cases it is plain that the true axillary branch has remained entirely undeveloped, for an axillary bud or bud scar can often be found at the base of one of the shortened branches. When no such mark is found it may be supposed that the axillary bud was carried out by the growing branch. It is seldom necessary to suppose that the axillary bud is directly transformed into a flower bud, since the existing conditions can also be reached by fusing the successive joints together, much as they are fused in the formation of a normal involucre.

The idea of translocation may be applied to these abnormalities of the Egyptian cotton, or it may be combined with the idea of hybridization, in view of the many intermediate stages between the parts that are normally quite unlike. The fact that sterility so generally accompanies these intermediate conditions is a further reason for looking upon translocation as a phenomenon akin to hybridization. Changes that might be looked upon as results of partial translocations of characters might also be considered as hybrid metamers or metameric hybrids. They represent abnormal intermediate stages between metamers that are quite unlike when normally developed. They indicate an abnormal intermediate expression of the characters rather than an abnormal transmission of characters to new parts of the plant. All of the hereditary characters are probably transmitted to all parts of the plant, since all of the internodes are able, directly or indirectly, to produce flowers and seeds, but the growth of the normal plant involves the full expression of each character in the appropriate place and its complete suppression in other parts of the plant. Failure of the proper suppression of a character

amounts to an abnormality, no less than the failure of a character to come into expression.

These abnormal intermediate forms of branches might also be compared to the hermaphrodite individuals that occur occasionally in plants that normally have the stamens and pistils on separate individuals, such as the fig tree, the date palm, and the hop vine. The diœcious habit is a condition of dimorphism inside the species. The abnormalities of the intermediate individuals support the analogy with hybridization. The behavior of hermaphrodite hop plants has been studied recently by Dr. W. W. Stockberger.[a]

These phenomena are of interest from the standpoint of the study of heredity as well as for agricultural purposes, since they show that characters having little or no direct relation to the external conditions may be seriously affected by changes of environment. New conditions appear to disturb the functions of heredity, not only to bring about substitution of characters and thus cause diversity between the plants, but they also appear to break down specializations inside the plant, to disarrange the patterns, as it were, of the different kinds of internode individuals that form the normal plant.

This conclusion does not refer alone to the fact that these abnormalities are very frequent in the newly imported varieties of cotton, but is also justified by the fact that different parts of the same field may differ distinctly in these respects, as the result of relatively slight differences of external conditions. Even in hybrids that are showing Mendelian segregations of parental characters of branching in the second generation, experiments in different places may give very different results. Hybrids between the Kekchi cotton of Guatemala and the Triumph variety of United States Upland cotton showed, in one place (Del Rio, Tex.), many Triumph-like plants with short basal branches, while at another place (Victoria, Tex.),

[a] Stockberger, W. W. Some Conditions Influencing the Yield of Hops, Circular 56, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1910, p. 11.

"In some sections hop vines are occasionally found which bear both staminate and pistillate flowers. Such plants are known locally as 'bastards,' 'mongrels,' or 'bull-hops.' When they occur they represent a total loss, so far as yield is concerned, since the few hops borne by these vines are inferior and never gathered. On the acre under consideration there were only five of these plants, but they have been observed in much greater proportion in other years and in other localities * * *. In 1908 a number of cuttings were taken from one of these 'bastard' plants and removed to a locality about 40 miles distant. The vines from these cuttings came into flower in 1909 and in every case reproduced the malformation of the original plant from which they were taken. In view of this fact care should be taken to prevent the use of cuttings from 'bastard' plants by promptly digging them out and destroying the roots as soon as they are observed. In this way their perpetuation may be prevented and the loss in yield due to their occurrence avoided."

the same stock of hybrids showed only long branches like the Kekchi parent. Hybrids between Kekchi and McCall, on the other hand, growing beside the Triumph hybrids, showed the short "cluster" branches of the McCall parent very definitely in both localities, and in approximately Mendelian proportions. In the equable tropical climate of Guatemala a planting of the McCall cotton failed to give any indication of the cluster habit that characterizes this variety in the United States.[a]

The frequency with which the abnormal intermediate forms of branches occur in all the different stocks of Egyptian cotton that are now being grown in Arizona increases the practical importance of this class of facts. The behavior of other types of cotton during the period of acclimatization has shown that new conditions of growth are able to disturb the processes of heredity and thus lead to many abnormalities of development and often to the complete sterility of the plants, either through failure to form any flower buds or through the abortion of all that are formed.

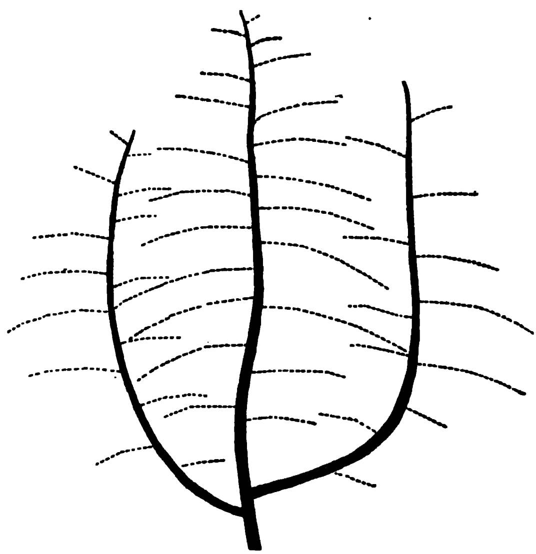

FIG. 1.—Diagram of a cotton plant with two vegetative branches and numerous fruiting branches.

Whether the production of these abnormally shortened branches of the Egyptian cotton is connected with the transfer to new conditions is not so plain as in the case of the abnormal transformations of fruiting branches into vegetative branches, but it is quite possible that the two conditions merely represent the extremes of one long series of variations. In the Dale cotton as grown near Yuma, Ariz., in 1909, the abnormal shortening and abortive tendencies of the branches were much stronger in the plants raised from imported seed than in those produced from seed raised at Yuma in 1908. The larger and more luxuriant plants also showed the greater tendency to abnormal shortening of the fruiting branches, instead of the usual tendency to elongate and change to the vegetative

[a] Cook, O. F. Suppressed and Intensified Characters in Cotton Hybrids, Bulletin 147, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1909, p. 23.

form. The analogy with the cluster habit of Upland varieties is often very strong, and in these also the tendency to abortion of the flower buds is often very great. Under favorable conditions cluster varieties of Upland cotton are sometimes extremely productive, but if unfavorable conditions supervene they are liable to wholesale abortion of the flower buds or the young bolls. The very strong tendency to fruitfulness defeats itself. The plant is under too great a strain of production and suffers the more acutely if conditions become unfavorable.

RELATION OF DIMORPHIC BRANCHES TO ACCLIMATIZATION.

The recognition of the different behavior of the two forms of branches is an essential step in the scientific study of many of the problems of cotton culture. One of the most striking illustrations of the significance of the dimorphism of the branches has been shown in the study of acclimatization. Central American varieties of cotton that grew under their native conditions as low, short-stalked plants with few limbs and numerous horizontal, fertile branches (fig. 1) showed in Texas a complete change of habits of growth, becoming large, densely leafy bushes, with many strong, sterile limbs, but with very few fruiting branches or none at all. (Compare figs. 1 and 2.)

FIG. 2.—Diagram of a cotton plant with numerous vegetative branches and no fruiting branches.

If the change had affected only the size of the plants, it could have been looked upon as a direct result of a rich soil or more favorable conditions of growth, but the complete unlikeness of the Texas plants to their Central American parents showed that other factors were involved. It was possible to raise large-sized plants which still retained the normal form and fertility of the type. The abnormal behavior of the plants was found to arise largely from the fact that sterile limbs were substituted for the normal fruiting branches.

mation of flowering buds. Varieties which have no vegetative limbs have no leaves except those of the main stem and the fruiting branches. Fruiting branches produce only as many leaves as flower buds, a bud at the base of each leaf. Varieties that do not produce vegetative branches must put on more flower buds in order to produce additional leaves.

Even when the weevils are not present a large proportion of the buds and young bolls of our Upland cottons are generally thrown off as superfluous, the vegetative energy of the plant not being adequate to bring them to maturity. Selection has probably tended toward the elimination of sterile branches in our Upland types of cotton. As long as the weevils did not enter into the problem, the superfluous buds, though no doubt causing a large waste of the productive energy of the plant, had a compensating value as a kind of insurance of the crop, for if in an unfavorable season the early buds were lost their places were filled by numerous successors as soon as the weather improved.

With the advent of the weevil it becomes a matter of importance to do away, if possible, with this persistent prodigality of bud formation. At the same time it is essential that the growth of the plant continue, at least to the extent of producing leaves enough to serve adequately the purposes of assimilating food for the growth of the bolls. The Kekchi cotton, by making use of primary branches, suggests a factor that has a relation to the problem, by showing how more foliage can be produced without the need of making the extra number of floral buds which are likely to serve only as breeding places for the weevils.

Many other kinds of plants, the great majority, indeed, have the determinate habits which would be so great an advantage in cotton in dealing with the weevil, for they produce buds and blossoms for only a short interval. Some plants can be made to continue in blossom by having their flowers picked so that seed can not set. To have educated the cotton plant to such determinate habits by selection might have proved a difficult and time-consuming labor. But with the realization of the fact that the cotton plant has two distinct kinds of branches, one of which does not produce flower buds, the task of finding or securing by selection a regularly determinate variety of cotton appears more definite and practicable. The possibilities of utilizing at the same time others of the numerous weevil-resisting adaptations possessed by the Kekchi cotton and other Central American varieties have received detailed consideration in a previous report.[a]

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[a] Cook, O. F. Weevil-Resisting Adaptations of the Cotton Plant, Bulletin 88, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1906.

The application of branch dimorphism to the problems of weevil resistance is not necessarily limited to early fruiting and determinate habits of growth. While early fruiting is undoubtedly an advantage under the ordinary conditions of cotton-growing communities, it does not necessarily follow that late-fruiting types of cotton will be permanently excluded from cultivation in all weevil-infested regions. Late-fruiting varieties must always suffer worse, of course, when grown with early varieties, but if the late-fruiting varieties were grown exclusively by whole communities the disadvantage would be less and might be avoided entirely if varieties were secured which were able to set a crop of bolls within a short time after the production of flower buds began. As long as the weevils were left without pollen to feed upon, and were thus unable to breed, the danger from weevils would not be increased. A quick-fruiting late variety, grown by itself, would have the same advantages of weevil resistance as an early variety grown under ordinary conditions, and with the prospect of being able to set a larger crop of bolls than the small plants of an extra-early variety.

DIMORPHIC BRANCHES OF THE CENTRAL AMERICAN RUBBER TREE.

The differences between the two kinds of branches in the Central American rubber tree (Castilla) correspond in some respects to those of the cotton plant. All the flowers and fruits are borne by one kind of branches, while the other kind has vegetative functions only, like the main trunk of the tree. But with regard to the origins of the two kinds of branches, the rubber tree is directly contrasted with the cotton plant. The fertile branches of Castilla always come from axillary buds, while the vegetative branches are always extra-axillary.

The diversity of function is carried a step farther than in the cotton plant, for the fertile branches do not become a permanent part of the tree. After they have borne two or three crops of fruit they separate neatly from the trunk and drop out of their sockets, which soon heal over. The dimorphic nature of the branches of the genus Castilla and the self-pruning habit of the fruiting branches have been described and illustrated in a former publication.[a]

Except in very rare instances, the fruit-bearing branches of Castilla remain quite simple and produce only leaves, followed in the next year by a cluster of flowers above each of the leaf axils. Growth takes place only at the end of the branch, leaving a longer and longer

[a] Cook, O. F. The Culture of the Central American Rubber Tree, Bulletin 49, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1903, p. 20, pl. 10.

naked section at the base after the successive crops of leaves and fruits have fallen. Finally the weight of the branch becomes too great for the support, the soft basal joint gives way, and the branch drops to the ground. The base of the branch is conical or rounded, and fits into a socket in the wood of the trunk. Both the base and the socket are marked with very fine radiating ridges and grooves, showing that the self-pruning habit of the tree is the result of a definite specialization of tissues and not a mere breaking or rotting away. In fact, the branch is usually still alive when it falls, and milk flows out of the tree into the exposed socket to cover the wound. The bark also soon grows over it and heals completely, leaving only a faint rounded scar.

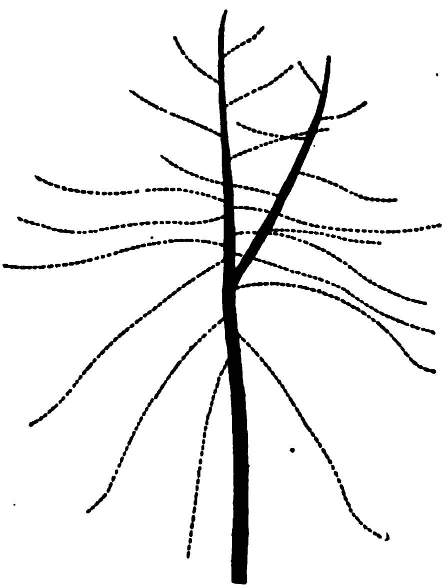

FIG. 4.—Diagram of a rubber tree with one permanent vegetative branch and numerous temporary fruiting branches.

The upright or permanent branches of Castilla are comparatively few in number. They arise, one in a place, at the right or the left of the base of a temporary branch, with the same regularity as in a stalk of cotton. They take a much more oblique or upright direction than the temporary or fruiting branches, which are usually nearly horizontal or somewhat drooping. The trees often grow to a height of 15 or 20 feet before any of the permanent branches develop, and then they often appear singly or a few at a time. (See fig. 4.)

The idea that extra-axillary buds are abnormal or exceptional appears to be quite as unwarranted in Castilla as in cotton. It would be possible for a Castilla tree to grow to seed-bearing maturity without producing any extra-axillary branches, but there would be formed in this way only a simple upright stalk or trunk. All of the branches that form the true permanent framework of the tree arise from extra-axillary buds that might be considered adventitious. Whether such buds are added after the formation of the internodes that bear them or are formed with the internodes and remain dormant at first is not certain. A permanent branch is often put forth at the base of a temporary branch that is still very young, in trees of sufficient age. That permanent branches of Castilla can arise as truly

adventitious buds is indicated by the fact that they often appear in considerable numbers along the edges of wounds, as when the bark is healing over gashes made in extracting rubber.

RELATION OF DIMORPHIC BRANCHES TO METHODS OF PROPAGATION.

There is no reason to suppose that the fruit-bearing branches of Castilla would take root, or that they could develop into normal trees. Sections of the trunk or of the permanent branches, on the other hand, take root readily, often when merely driven into the ground as fence stakes. In the Soconusco district of southern Mexico many instances were observed in which rubber trees were growing with apparent health and vigor from plantings as fence stakes. One of the largest rubber trees in the vicinity of Tapachula is said to have grown from a fence stake.[a]

The fact that the Central American rubber tree is capable of being propagated from cuttings is of practical interest in connection with the great differences in yields of rubber from individual trees. Though external conditions are undoubtedly responsible for some of the differences, there is every reason to believe that the characteristics of the individual trees will prove as important as among other cultivated plants. A system of vegetative propagation would enable such differences to be utilized directly, whereas an attempt to develop improved strains that would come true to seed might require many years of breeding. The utilization of the increased vigor and fertility of hybrids might also be made possible by a system of vegetative propagation.

The use of large cuttings in setting out new plantations would have cultural advantages in more quickly reestablishing the forest conditions that are now considered desirable in rubber plantations. Two of the systems of managing plantations that were quite popular at first have been found to have serious disadvantages. The leaving of the old forest to keep down the undergrowth by shade interfered also with the growth of the young rubber trees. Clean culture allows the trees to grow very rapidly at first, but their later development may be checked if the fertile surface soil is washed away and harmful grasses become established. The cleaning of the grassy plantations becomes more and more expensive, and also more and more harmful. The expected rate of growth of the trees is not maintained, and the period of profitable production of rubber recedes into an indefinite future.

Other difficulties in rubber culture come from the refusal of the latex to flow from the trees. Even when an encouraging yield is

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[a] Cook, O. F. The Culture of the Central American Rubber Tree, Bulletin 49, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1903, pl. 9.

obtained from first tappings, later attempts to secure latex from the vicinity of an old cut may be very disappointing. In the Para rubber tree (Hevea) there is a so-called "wound response" that results in continued and increased yields of latex from the paring back of the edges of the wounds, but in the Central American rubber (Castilla) the tapping of the bark in the vicinity of old cuts may bring out very little latex. The bark pressure that forces the latex out of new cuts is not restored around the old cuts. Only a small proportion of the latex is extracted by the present methods of tapping; the rest remains and dries up in the bark. If bark could be produced more rapidly by vegetative propagation, it might become practicable to harvest the bark as well as the latex and extract the rubber by mechanical means. Branches from the more productive trees would be available for extending the plantation.

THE PRUNING OF RUBBER TREES.

The fact that the rubber tree prunes itself so extensively leaves little work of this kind for the planter to do, but two precautions are not unworthy of consideration. The self-pruning mechanism does not always work successfully. If growth is very rapid the trunk may enlarge around the bases of the temporary branches and hold them in place, even after they are dead. This is also likely to happen when a branch has been injured or dwarfed, and thus lacks the weight necessary to break it away from its socket. Such decaying branches may give fungi or insects an entrance to the wood of the tree and thus induce decay. It would require very little additional labor to keep the plantation entirely clear of them. In most cases a pole with a simple hook or elbow at the end would enable them to be pulled out of their sockets, which would be better than cutting them off. The pruning away of some of the permanent branches may be desirable in the occasional instances where these come out too low down. The earlier these are removed the better, to keep the trunk of the tree smooth and erect for purposes of tapping.

DIMORPHIC BRANCHES OF COFFEE.

The upright branches or limbs of the coffee shrub are the equivalents of the original main stem; they bear no fruit, but can give rise to other uprights and to lateral branches. (See Pl. III.) The laterals bear flowers and fruit, and can also give rise to other branches of the same form and function, called secondary laterals, or simply secondaries, but no lateral branch ever produces a true upright branch. Unlike the cotton plant and the rubber tree, each internode of coffee bears two opposite leaves and is capable of producing two sets of branches, two axillary and two extra-axillary. In

are cases an internode may bear three leaves and the branches may tand in whorls of three.

The buds that give rise to the upright limbs make their appearance n the normal position, in the axils of leaves, but the lateral branches levelop in advance of the leaves of the joint to which they are atached, and appear to arise from near the bases of the joints or interodes of the uprights, instead of from the ends of the joints. (See Pl. IV.) They do not appear to have any connection with the leaf which is nearest them below. There is no difference of texture or ine of separation between the upright and the young lateral branch. Both are covered from the first with the same continuous skin or pidermis, without groove or wrinkle. The lateral branches do not fall off or separate from the upright except by decay.

The lateral branches are always formed while the joint is young and growing, instead of pushing out afterwards, as do the adventitious or dormant buds. In this respect there is an abrupt difference between the primaries or first generation of laterals and the second generation or secondary laterals. These arise from the primary laterals at the axils of the leaves. Secondary laterals are seldom produced when the uprights are allowed to grow normally, but the growth of secondary laterals can be forced by severely pruning the uprights. Under unfavorable conditions, where the growth of the plants is alternately checked and forced, the formation of supernumerary secondary laterals represents a diseased condition, somewhat resembling the "witches'-brooms" of some of our northern trees. (See Pl. V.)

The axils of the lateral branches usually produce only flowers and fruits. The floral buds appear in large numbers clustered on several very short axillary branches. The secondary laterals can thus be understood as representing sterilized floral branches. Flowers are not normally formed on uprights. In the Bourbon coffee, which is abnormally prolific in flowers, the uprights are occasionally fertile to a slight extent.

PROPAGATION OF COFFEE FROM OLD WOOD OF UPRIGHT BRANCHES.

The prevalent idea that coffee can not be grown from cuttings has arisen, presumably, from attempts made with lateral or secondary branches (fig. 5). Pieces of the main stem or of upright branches take root readily and produce entirely normal trees. Several very successful examples of vegetative propagation of coffee from upright branches have been seen in Central America, though all were results of accidents, not of any definite intention to apply a new method. In such towns as Coban and Purula, in the coffee-growing districts of the mountains of eastern Guatemala, one often finds fence stakes of

old coffee wood putting out new shoots and forming new tops like vigorous young trees in a plantation.

Other cases were found in Costa Rica on the large coffee estate of Señor Don Federico Tinoco at Juan Viñas. Straight stakes cut from old coffee trees had been used to support the bushes in the rose garden of Señora Tinoco, and had promptly taken root. They had been allowed to grow, and had all developed into large, well-formed, productive coffee trees. Such instances certainly demonstrate the possibility of producing normal coffee trees by vegetative propagation. As there are considerable differences of soil and climate between Costa Rica and eastern Guatemala, it appears that such propagation is not narrowly limited to one set of conditions.

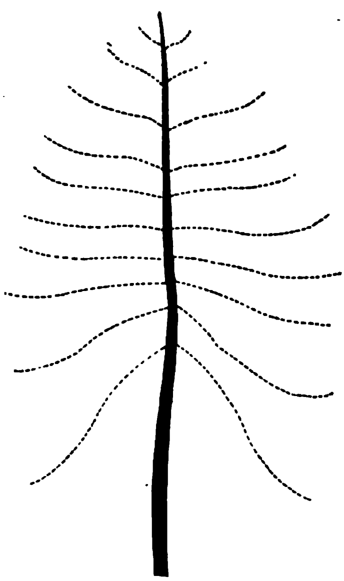

FIG. 5.—Diagram of a coffee tree with a simple trunk and numerous lateral fruiting branches.

If a system of vegetative propagation could be applied to coffee by the use of cuttings of the upright branches (fig. 6), several important cultural advantages might result. Much of the labor and expense now required for seed beds, nurseries, and transplanting would be saved, and plantations might be brought more rapidly to the size when good crops are produced and the ground is well shaded by the trees. The latter condition not only reduces the cost of cleaning the land of weeds, but protects it from injurious exposure and erosion.

The possibility of improving the coffee crop by the development of superior hybrid varieties also depends upon the use of some system of vegetative propagation, or upon the grafting of the young seedlings, as has been proposed in Java and other tropical countries. At present we have only the so-called Arabian type of coffee and the several mutative varieties which have been selected from it. Most of these, if not all, are inferior to the parent stock in fertility. Although very satisfactory in the matter of coming true to seed, they all seem to lack the first essential of an improved type, for they are generally less fertile than the parent stock.

In addition to the precaution of using the upright branches, other methods of treating the propagating stock will need, of course, to be worked out. It is quite possible that the cuttings can not be used in

fresh condition, but may need some process of curing after they are cut, such as would allow new tissues to form on the cut surfaces before they are placed in the ground. In the successful cases of propagation from cuttings mentioned above, the wood had come from old trees that had been taken out of the plantations. Time may also have elapsed between the cutting of the stakes and the setting of them in the ground.

RELATION OF BRANCH DIMORPHISM TO THE PRUNING OF COFFEE.

The habits of growth and cultural requirements of coffee, and especially the principles of the art of pruning, can not be clearly understood without the recognition of the two kinds of branches. Planters who reason in a general way, without taking into account the dimorphism of the branches, often suppose that the pruning back of the uprights at the growing ends will cause them to send out new lateral fruiting branches lower down. This is a mistake, for new lateral branches are formed only on young, growing uprights, and then only two of the laterals from each joint of the upright.

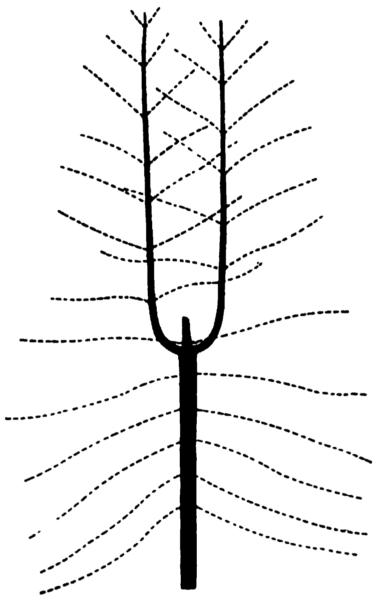

FIG. 6.—Diagram of a coffee tree with two upright branches and numerous lateral branches.

Additional development of lateral branches is to be obtained from mature uprights only by forcing the primary laterals to send out secondary laterals. If the primary laterals have been cut off no secondary laterals can be formed. Severe cutting back of the main trunks or upright branches is usual as a means of forcing more vegetative growth in the lateral branches. If the pruning is too slight it may have the effect of merely causing the primary laterals to elongate without forcing them to send out secondary lateral branches, for it is not a normal habit of the coffee tree to produce branches from the laterals. Left to itself without pruning, coffee usually produces only simple laterals and forms new lateral growth only through the medium of new uprights.

When all the axillary buds of the main stem have been eradicated no new uprights can be formed. If the tree continues to thrive, it spreads out on the ground as a tangled mass of slender decumbent

lateral branches. It is the custom of planters in Jamaica, according to Mr. G. N. Collins, of the Bureau of Plant Industry, to pull off the uprights instead of cutting them, on the ground that this prevents the growth of any more uprights. It is easy to understand that additional uprights may develop from buds of short basal joints of uprights that have been cut off, but this would not be the case with uprights that are pulled out. An additional bud can be seen on Plate IV, underneath the base of one of the new uprights that have been forced by pruning.

If the fertility of a plantation is to be maintained, resort must be had to some form of pruning, in order to continue the formation of healthy new wood on which good fruit can be borne. Old trees that are not pruned tend to produce slender branches, narrow leaves, and very small fruit. New wood can be obtained by allowing new uprights to develop or by preventing the growth of the uprights and forcing the laterals to branch. The use or the rejection of the uprights affords a fundamental distinction between the several different systems of pruning coffee.

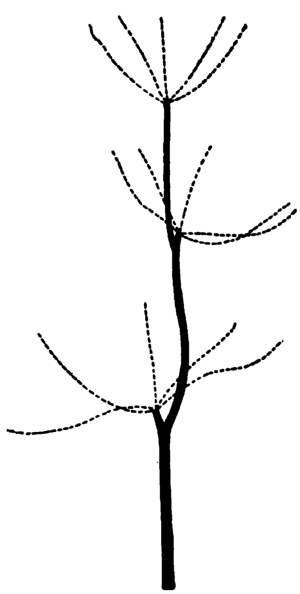

FIG 7.—Diagram of a cacao tree with three upright shoots and three groups of whorl branches.

The subject is one of too great extent and complexity to be discussed in detail here. Methods that may be thoroughly justifiable and advantageous under the conditions of one coffee-growing district may be objectionable in another, or even destructive, so greatly do the habits of the plants differ under different conditions of climate and soil. The practicability of the different systems of pruning depends also very largely upon the character and cost of labor. In some countries the natives show much aptitude for such work, but in others only the simplest systems can be applied; the cost of skilled assistance would be prohibitive.

DIMORPHIC BRANCHES OF CACAO.

The cacao tree bears two distinct kinds of branches, but these do not correspond directly to those of the rubber tree, the coffee, or the cotton. The fruit-bearing function is not confined to either type of branches. Both have vegetative functions, and both produce the small leafless twigs that bear the flowers and fruits. Even the main

trunk of the cacao tree produces flowers and fruit in the same way as the branches. In other words, cacao is cauliflorous.

The two kinds of vegetative branches can be distinguished readily by their position and also by the fact that they bear different kinds of leaves. The trunk elongates by a succession of upright shoots, each of which is terminated by a cluster or whorl of branches (fig. 7). (See Pl. VI.) The main stem and the upright branches have leaves with distinctly longer petioles than those of the lateral branches. The petioles of the leaves of the uprights are often 3 inches long, while those of the whorl leaves are less than an inch. (See Pl. VII, fig. 1.)

In the patashte tree (*Theobroma bicolor*), a relative of the cacao that is being introduced into cultivation in Guatemala, the specialization of the leaves of the two types of branches is carried still farther. The leaves of the main trunk and the upright limbs have petioles 8 or 10 inches in length, while the leaves of the secondary or lateral branches have petioles only about 1 inch long, as in the cacao. The blades of the two kinds of leaves of the patashte are also very different in size, shape, and texture, instead of being nearly alike as in the cacao.[a]

When a cacao seedling has grown a simple straight stem to a height of 2 to 4 feet, the single terminal bud gives place to a cluster or circle of three to six small buds, from which arises a whorl of as many branches. (See Pl. VI.) These branches soon diverge in a horizontal or oblique direction, but curve upward toward the end. In the petashte tree the number of branches in each whorl is always three, but in the cacao there are usually four, often five, and occasionally six. The whorled branches do not continue the upward growth of the main stem or trunk of the tree, but a new shoot for this purpose appears, in due time, on the side of the trunk, often an inch or more below the terminal whorl of branches. This lateral shoot curves upward and passes between two of the whorled branches into a vertical position, grows a few feet upward, and divides into another whorl of branches. Later on these upright sections seem to straighten more and more until the clusters of branches, which had previously terminated the trunk at its different stages of growth, are pushed over to the side, as though they were lateral clusters.

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[a] The patashte tree also differs from the cacao in not being cauliflorous. The short inflorescence branches do not rise from the old wood of the main trunk and larger basal branches, but are confined to the axils of new leaves near the slender growing ends of the branches. The patashte is a much taller tree and grows much more rapidly than the cacao. It is usually from 12 to 20 feet high before it begins to branch, instead of branching within 3 or 4 feet of the ground, as the cacao usually does.

RELATION OF DIMORPHIC BRANCHES TO HABITS OF GROWTH.

Other cacao trees, both wild and cultivated, fail to show these habits of growth. Instead of the erect main stem, with branches in rosette-like clusters, the trunk divides near the ground into many oblique arms that form a broad spreading top of dense foliage, entirely unlike the open, irregularly distributed foliage of the trees with tall upright trunks. Planters of cacao have recognized cultural differences between the two forms of trees, the low, spreading type being preferable for plantation purposes to the tall type with the whorled branches.

It has been supposed that the different habits of growth betoken two different varieties of cacao, but seedlings from the spreading trees have not been found to show any tendency to reproduce the spreading habit of growth. If the spreading trees had any other character in common, the idea of a varietal difference might still appear to have some justification, but the fact is that both kinds of trees show the same general range of individual differences in the characters of the fruits, which are the only parts of the plant that lend themselves to careful comparison. The serious difference lies in the fertility, for the low, compact trees that shade their own short trunks and the ground underneath them appear to thrive much better in plantations than trees of the other type, and bear larger crops. In eastern Guatemala, where this matter was studied in some detail, it was the opinion of a very intelligent cacao planter, Don Ricardo Fickert-Forst, owner of the Trece Aguas estate, that the low, spreading trees would bear, on the average, at least twice as much cacao as the others, and that they would continue to be fruitful for a longer period of years. Efforts had been made to obtain more of the spreading trees by planting seeds from trees of this form.

The failure of such attempts can be explained after the serious differences between the two kinds of branches are recognized. The low, spreading trees have this desirable form because they do not produce any of the upright shoots and whorls of branches. Their method of branching is the same as that shown on whorl branches, that are incapable of forming uprights, as already explained. Although there is no indication of a whorled arrangement of the main branches of the spreading trees, it may nevertheless be considered that the tops of these trees represent the development of only one or two of the branches of an original whorl, and this would afford an adequate explanation of the formation of a different type of tree.

The inability of the whorled branches to produce any upright shoots would explain why a tree top formed from such a branch would not have any of the strong upright shoots, but would produce

only the relatively slender oblique or lateral shoots proper to the branches that are formed as members of a whorl. If only one or two of the branches of the first whorl were to survive and to begin branching near the base, the further growth of the tree might come from the development of these whorled branches, the upright type of the branches falling into complete abeyance. The question of being able to produce at will the desired type of tree appears to turn on the treatment of the young tree at the time it puts out the first or second whorl of branches.

RELATION OF DIMORPHIC BRANCHES TO THE PRUNING OF CACAO.

Recognition of the dimorphism of the branches of the tree is a matter of even more fundamental cultural importance with cacao than with coffee, since it enables us to understand differences in habits of growth that determine the productiveness and even the life of the trees. Much of the advice regarding the pruning of cacao has been given without regard to the dimorphism of the branches, and is misleading, if not actually dangerous. Some writers have recommended the removal of some of the branches of the lowest whorl if the tree begins to branch too low down, and others have held that only three or four of the whorl branches should be allowed to develop when five or six are produced. In neither case has it been considered that the preliminary treatment might have the effect of a complete alteration of the habits of growth of the tree.

If the production of whorled branches is to be allowed to continue so as to produce trees of the upright, open form, it is very doubtful whether any advantage can be gained by removing a few of the branches of a whorl. The effect is to weaken the basal ring of wood that supports the whorl in its rather precarious position at the end of the long, upright shoot. When the strength of this ring is diminished the weight of the branches is likely to split them apart. Moreover, the wood of the cacao tree is so soft that decay is very likely to follow any injury—another reason why any attempts at pruning should be confined to the very youngest stages of the growth of the branches.

If an attempt is to be made to compel the young tree to form its crown from one or two of the whorl branches, it is also very important that these keep the more nearly upright position that they have in their early stages. If pruning be delayed until the whorl has opened out and the branches have become nearly horizontal, the chances of having a well-shaped crown are very small. It may also be desirable not to let the branches that are left grow too long. Pinching off the end when they are about a foot long would force

them to send out secondary or lateral branches near the base and thus assist in forming a compact, well-shaped crown. With two or more strong branches from near the base of a single whorl branch a condition somewhat similar to the original whorl may develop, but essentially different in the subsequent habits of growth, since these branches do not tend to spread apart like true whorl branches, and are able to continue the upward growth of the tree without the formation of any more upright shoots from the main trunk.

A further indication that the habit of forming the whorled branches represents a definite specialization may be found in the fact that the upper leaves of an upright are often aborted. The stipules are of the normal size, but the petioles and blades do not develop. The stipules soon drop off, leaving small scars on the surface of the bark as the only indication of the joints.

It is not clear whether this habit of forming abortive leaves is to be viewed as an adaptation to avoid the clustering of too many leaves at the top of an upright shoot, or is connected with the shortening of the internodes to form the whorl of branches. When the leaves are aborted many short internodes are likely to be formed below the whorl. In other cases there are no abortive leaves. Even the whorled branches may arise from axils of normal, full-sized leaves, but in such cases the whorl is likely to be somewhat irregular, as though the internodes had not been sufficiently shortened.

If these reduced leaves are taken into account, the cacao tree may be said to have three kinds of leaves, the leaves with the long petioles on the lower parts of the uprights, aborted leaves at the ends of the uprights, and short-petioled leaves on the whorled branches. The specialization of the leaves of the cacao is somewhat similar to that of the pine tree. Young seedlings and new shoots of pines that have been cut down or severely pruned have functional green leaves all along the shoot. Ordinary shoots and branches of pine trees have no functional green leaves, but only scalelike membranous sheathing leaf bases. The functional leaves of adult pine trees represent the terminal clusters of a few leaves at the ends of very short specialized branches that appear to be incapable of further growth. New branches have to be developed from special zones where the axillary buds of the leaves of the uprights remain dormant instead of producing the short leaf-bearing branches.

The habit of the cacao tree to produce the long uprights with a whorl of branches at the end appears thoroughly undesirable from the cultural standpoint, but if we consider the habit of the wild cacao to grow in dense thickets with many other kinds of woody vegetation its peculiar habit of growth may be seen to have some advantages. The rapid growth of the upright shoots enables a cacao tree to raise

a terminal whorl of branches above the surrounding vegetation, and thus secure an amount of exposure to sunlight that might not be obtainable otherwise. Though the cacao must be reckoned as one of the shade types of vegetation it does require light. The most vigorous and productive cacao trees are those that stand out in full exposure to the light, but the soil conditions must be very favorable to enable the trees to thrive with full exposure.

FIG. 8.—A broad-leaved sucker of a banana plant from Costa Rica. (Greatly reduced.)

DIMORPHIC BRANCHES OF THE BANANA PLANT.

Although the habits of growth of the banana plant are altogether different from those of the shrubby and woody species previously described, there is a definite dimorphism of branches that has to be taken into account in studying the habits of growth and the problems of cultivation. Banana planters regularly distinguish between "sword suckers" and "broad-leaved suckers," but the nature and the extent of the differences between the two kinds of offshoots have not been adequately appreciated. The effects of external conditions have been supposed to explain the differences, although both kinds of branches are almost always to be found on any well-developed plant.

The names of the two kinds of offshoots allude to differences in the size and shape of the leaves. The broad-leaved suckers begin near the ground to produce leaf blades of the same general form as those of the adult plant (fig. 8). The sword suckers produce at first only small narrow blades that by their shape suggest the name (fig. 9). The basal, sheathing parts of the leaves that form the so-called "trunk" of the banana plant are much larger in the sword suckers, and this renders the reduction of the blade of the leaf a more evident specialization.

FIG. 9.—Sword suckers of the commercial banana, used in setting out plantations in Costa Rica. (Greatly reduced.)

Possibly the dimorphism of the branches is not as definite in the banana as in the woody plants previously considered. Though no connecting stages between the two kinds of branches were noticed in the rootstocks that were dug out and examined, it may be that intermediate conditions will be found occasionally, as in Indian corn. The intermediate joints of corn plants, between the ears and the suckers, seldom develop branches, but when such branches are developed they are intermediate in form, as well as in position.

The differences in the development of the leaves call attention at once to the fact that the two kinds of banana suckers stand in different relations to the parent plant. The broad-leaved suckers, with their relatively large, expanded leaves, are able from the first to elaborate a larger part of the nourishment they require than are the sword suckers, yet in spite of this apparent advantage the broad-leaved suckers are of much slower growth. It is evident from this fact that the sword suckers stand in a different relation to

the parent plant and draw a much larger proportion of nourishment from it.

These differences of relation are made still more obvious when it is learned how the two kinds of branches originate. The broad-leaved suckers come from buds around the sides of the rootstocks, near the surface of the ground. The sword suckers begin their development deep in the ground, underneath the parent rootstock. They have at first the form of slender, subterranean shoots, that grow first in a horizontal direction or even obliquely downward. They thicken into a large fleshy bulb before beginning to grow much above ground. (See Pl. VII, fig. 2.)

The sword suckers may be looked upon as true permanent branches of the parent rootstock, while the broad-leaved suckers are better adapted for separate propagation under natural conditions. Many of the latter are put out above the surface of the ground. Some of them have at first the form of small, rounded tubers, the buds remaining entirely dormant. A banana plant that has been uprooted by the wind does not die at once, but puts out from about its base a large number of these potato-like tubers, which finally fall off and are readily scattered, or roll down hill. The wild relatives of the banana plant are natives of steep, rocky hillsides, where such a method of vegetative propagation would be distinctly advantageous.

CULTURAL VALUE OF TWO TYPES OF OFFSHOOTS.

Banana planters generally follow the rule of using the sword suckers in setting out plantations, on the ground that they produce fruiting plants quicker than the broad-leaved suckers. This is easy to believe, in view of the larger amount of stored nourishment that is carried over to the new plants by using the much thicker bulb of the sword suckers instead of the relatively small rootstocks of the broad-leaved suckers. Some planters in Costa Rica doubt whether the broad-leaved suckers ever produce fruit of their own, and are inclined to believe that fruiting does not begin until the necessary sword suckers have had time to grow. In Jamaica, on the other hand, the sword suckers are cut back nearly to the ground before planting and the first crop comes from the growth of new suckers.[a]

[a] See Stockdale, F. A., "The Question of a Banana Industry," Journal of the Board of Agriculture of British Guiana, vol. 3, no. 2, 1909, p. 79.

"The suckers which would be selected for planting [in Jamaica] are not the same as those that would be chosen in this colony [British Guiana], and the method of treatment is totally different. Suckers for planting purposes are suckers that have not been cut back, or in other words, 'sword suckers'—as indicated by their first leaves being very narrow—which have been allowed

The use of the most vigorous suckers appears especially important, not only to obtain the earliest possible crop from a new plantation, but because it is also highly desirable for a new plantation to grow up rapidly and shade the ground as soon as possible, thus protecting itself from harmful weeds and lessening the cost of cultivation. The later welfare of the plantation may also be affected by its early prosperity. The shading of the ground not only helps to maintain favorable soil conditions and thus conduces to larger crops, but larger numbers of the quick-growing sword suckers are produced in prosperous, shady plantations. The exposure of the base of a banana plant to much light appears to stimulate the formation of broad-leaved suckers, as though the plants had the intention to occupy the surrounding land before turning their attention to the production of fruit.

THE PLANTING OF RESTING TUBERS.

Although the production of many broad-leaved suckers may be considered to represent an unfavorable condition in a plantation, they are not without interest and utility from other points of view. The much greater abundance in which the broad-leaved suckers are produced would render them of very distinct importance in any attempt to propagate a new variety or special strain derived from a single superior plant. A rootstock can not be expected to produce more than three or four sword suckers at one time, while a score, or perhaps several scores, of broad-leaved shoots might be obtained if a plant were treated with this end in view. Study might well be given to the finding of differences in habits of branching. A strain that would produce only a few suckers would be more valuable in the plantation, for the pruning away of superfluous suckers is one of the chief items of expense in many banana plantations. Such a strain might be at a disadvantage, however, in furnishing stocks for new

to grow to about 8 or 10 feet in height and which have large bulbs at their base. No small suckers, such as we choose in this colony, are taken. In preparing their suckers for planting the Jamaicans cut down those selected to within about 6 inches of the ground and then dig out the bulbs. All the old roots are then trimmed off, and the bulb is planted so that the eyes are at least 3 or 4 inches below the level of the ground. From this bulb three or four suckers will spring up. The strongest one is selected, and all the others are pruned off until June, when one or two suckers are left, and then, again, all others are pruned off until October, when there is again left either one or two, and finally another is left the following February. It is calculated that the first suckers should fruit in the following March, the June suckers in May, the October ones in February or March, twelve months, and the February one in May or June, twelve months. This system for timing is the outcome of long experience and could not be adopted in this colony without modification on account of differences in climatic and rainfall conditions."

plantations, unless it could be made to yield more numerous offshoots when these were required.

The use of the hardened resting tubers may be considered as the ideal condition for shipping propagating stock of the banana from one country to another. The question of diversifying the American banana industry by the importation of some of the superior types of banana of the Old World has often been raised. One of the difficulties has been to obtain new stocks in sufficient quantity, even for adequate experiments to be made. This has appeared to stand in the way of any immediate practical results being obtained, and has undoubtedly tended to discourage attempts to obtain superior varieties.

It is also possible that the broad-leaved suckers may be found useful in dealing with some of the banana diseases that appear to indicate a weakening of the vitality of some of the best strains of the commercial banana, as in the case of some of the superior varieties of sugar cane. The sugar planters of Java bring down new stock from the mountains, because the mountain-grown canes have been found more resistant to disease than the same variety grown continuously in the lowland plantations.

The tuber-like, broad-leaved suckers that are formed on uprooted banana plants may be looked upon as a resting state, and may be expected to have a relation to subsequent vigor of growth. An interruption of growth might be directly beneficial, or if different conditions prove to be necessary, as in the case of the sugar cane, the tubers would greatly facilitate the exchange of propagating material. They could be collected and transported from one district to another much more readily and cheaply than the large, heavy sword suckers.

As a means of testing the possible effect of the resting stage upon the subsequent behavior of the plants, a suggestion was made in 1903 to Prof. H. Pittier, who soon after took charge of the experimental plantations of the United Fruit Company in Costa Rica, that plantings be made of these potato-like tubers to see whether any differences of behavior would be shown. In 1904 a hectare (about 2½ acres) of land was planted with these small resting tubers, instead of the usual sword suckers. The growth of the plants was unexpectedly rapid and did not fall behind that of the neighboring fields that were planted with large sword suckers. The first crop was matured in about nine months, the usual time under the Costa Rican conditions, and with more than usual uniformity, each plant producing a large, well-formed cluster of fruit. It was also noticed that the plants of this field produced very few suckers around the base until after fruiting, in very distinct contrast with adjoining fields planted with the sword suckers. When Professor Pittier made a visit to Costa Rica in 1907, three years after the beginning of the

experiment, this field still appeared very distinctly superior to any of the adjoining areas.

Although no observations or tests were made to determine the resistance of these plants to disease, it is apparent even from this single experiment that commercial crops of bananas can be produced under conditions that would give a considerable measure of protection against disease. The resting tubers would be much less likely to convey diseases than the sword suckers, and could be much more easily disinfected. Some of the banana diseases that become very serious in old plantations appear to have little or no effect upon vigorous young plantations under favorable conditions. The more frequent replanting of bananas, every two or three years, is being advocated among the Jamaica planters, because the old stocks are thought to "run out" and become less vigorous, and also because the young plants can be brought into fruit with greater regularity.[a]

The possibility of producing a full and regular crop of large clusters of fruit by the use of tubers instead of sword suckers would also make it more feasible to use bananas in a rotation of crops, a policy which may prove to be as desirable in tropical cultures as in those of temperate regions, if a permanent use of the land is to be maintained. If the destructive policy of raising bananas for a few years and then abandoning the land continues to be followed in Central America, it will probably not require many decades to exhaust all the districts that are well suited to banana culture and at the same time readily accessible from the United States. In a few favored spots where soil conditions are ideal or where new soil continues to be deposited by floods of adjacent rivers, permanent cultures may be maintained, but in most places the prosperity of a banana plantation appears to have definite natural limits.

COMPARISONS OF DIFFERENT SYSTEMS AND TYPES OF BRANCHES.

One reason why dimorphism of branches has not received more attention is doubtless to be found in the fact that current botanical classifications of buds and branches do not provide adequate recognition for the different kinds of diversity shown by the branches, as among these tropical crop plants. The view generally stated or implied in text-books is that branches are to be divided, with reference to their methods of origin, into two principal kinds, axillary

[a] "There is a growing tendency throughout the whole island to reduce the period of ratooning and to replant every two or three years, as it is found that by so doing the crops may be better timed for the American market, as after first ratoons the plants fruit somewhat irregularly." (See Stockdale, F. A., "The Question of a Banana Industry," Journal of the Board of Agriculture of British Guiana, vol. 3, no. 2, 1909, p. 81.)

and adventitious. This compels us to infer that branches which do not come from the axils of the leaves must be regarded as adventitious, or to some extent irregular and abnormal.

It may be that the present series of facts of dimorphism will incline botanists as well as planters to take into account the normal ind regular existence of branches which are neither truly axillary ıor truly adventitious. It is as impossible to understand the habits of growth of the plants from the botanical standpoint as it is to find correct principles of cultivation and pruning without seeing that he same plant can produce two or more kinds of branch organs ssentially distinct from each other in position, form, and function.

The different systems of branching have evidently been specialized n independent lines that could hardly be described on the basis of he usual classification of branches into two general classes—axillary nd adventitious. There should be no implication that extra-axillary uds are of necessity adventitious, or that extra-axillary or adventitious buds are less important in any particular plant than axillary uds. There are no general relations between the position and the unction, nor between the position and the time of appearance, nor et between the time of appearance and the function. There are no eneral principles that apply to the dimorphic branches of all the ifferent plants, nor do any two of them fully agree.

The extra-axillary branches of the coffee have the fruit-bearing unctions of the axillary branches of Castilla, while the axillary prights of coffee correspond functionally to extra-axillary uprights f Castilla. The axillary branches of Castilla must be considered s more definitely limited on the vegetative side than the extraxillary branches of the other plants, in view of their temporary ature.

The specializations shown in the branches of the cotton plant are some respects quite the opposite of those of the Central American ubber tree. The flowers and fruit of the cotton plant are borne on tra-axillary branches, those of Castilla on the axillary branches. he vegetative limbs of Castilla are all extra-axillary, while those cotton are axillary. The axillary or fertile branches of Castilla e temporary, while the extra-axillary serve as permanent divisions the main stem.

Coffee agrees better with cotton than with Castilla, since it is the illary buds which give rise to the permanent, upright shoots. The tra-axillary branches of cotton and coffee are also alike in the bearg of fruit. Though extra-axillary in position they can hardly be lled adventitious. Indeed, they are less adventitious than the axillary anches, for they are developed with far greater regularity. Extraillary buds in cotton and coffee seem to lack the power of remaining

dormant. They do not appear to be present on young plants, and they are never added after the internode and its leaf or leaves have become mature. They are laid down with regularity as a part of each internode of the adult plant.

The extra-axillary buds, both in cotton and coffee, are developed with the same invariable regularity as the leaves themselves. They resemble adventitious buds only in the technical sense that their position is extra-axillary. Considered from the standpoint of the habit and functions of the plant, they are not more adventitious than the terminal or the axillary buds.

Before the young internode emerges from between the stipules of the coffee leaves, the three buds that give rise to the central axis and the two lateral branches can be found standing in a row with the axillary buds and only very slightly above them. Later on the three buds are pushed out nearly together, but the middle one soon leaves the other two behind. Strictly speaking, therefore, the extra-axillary branches of coffee arise from subterminal buds. After the branches are formed there is no internal indication of a joint or septum; the pith is quite continuous. Thus an internode of a main stem or an upright branch of coffee does not appear to be a simple cylinder, but a three-armed fork or trident.

The lateral branches of the coffee plant do not normally branch again, though they can be forced to do so by pruning. The secondary lateral branches are produced from sterilized flower buds, and have only the characters of laterals, never of uprights. Persistent pruning may exhaust all the buds capable of forming uprights and leave the tree a tangle of horizontal or drooping branches, apparently without the power to put forth any more uprights.

Branches of definitely limited possibilities of vegetative growth, like the fruiting branches of coffee and Castilla, may be considered as having intermediate functions between those of leaves and of ordinary types of vegetative branches. The leaves of Begonia and Bryophyllum, which produce plantlets from adventitious buds, and the leaf-like flower-bearing organs of Phyllanthus and Phyllonoma represent other intermediate stages between ordinary leaves and branches. The leaf-like branch organs of some of the relatives of asparagus, such as Ruscus and Semele, might be mentioned in the same connection. Even the tobacco leaf may develop a row of vegetative buds along the base of the midrib. The axillary branches of Castilla are as definitely deciduous as the leaves. The permanent branches of coffee are formed from axillary buds, while those of Castilla appear to be adventitious as regards the time of development, though they have definite positions.

Unless the different branch organs are to receive distinctive names in each of the different plants, it will be necessary to content our-

elves with a few general terms that will enable us to indicate more irectly the nature of these various kinds of branches. A primary istinction can be made as to whether a bud is laid down when the ranch grows or is formed afterwards from unspecialized tissues of ıe bark. Buds that are not adventitious in the latter sense, but are ormed with the growth of the internode to which they belong, might e called natal buds.

Adventitious branches are not supposed to have regularity of posiion, but such regularity should not be allowed to obscure their adentitious character if they are formed subsequent to the growth of ıe internode. The loss of the original axillary bud may be followed y the development of an adventitious axillary bud, as happens in offee. Also the flower buds of coffee appear to be adventitious to a ery considerable extent, and perhaps altogether so. With severe runing, leafy branches may also be forced from the axils of the aves of the fruiting branches long after the normal production of owers and fruits would have ceased. This may be taken to show ither that additional adventitious buds can be formed in the axils fter the fruiting period is past, or that the axillary buds of the ruiting branches have previously remained dormant and not taken art in the production of flowers and fruit.

The fact that flower buds can be adventitious only emphasizes the ore the absence of any general connection between origins, positions, nd functions, for plants have always had flowers, or at least the sential sexual organs, even before they had the present specializations f their vegetative parts into branches and leaves. Flower buds could ever be considered adventitious if we were to attach any functional nse to the term, but they appear adventitious with respect to the me and method of origin on the individual plant.

The terms axillary and extra-axillary are sufficient, perhaps, for e designation of the positions of the two kinds of buds on any parcular plant, but as a general term extra-axillary is extremely infinite. It groups together buds arising from internodes of the stem trunk and those coming from the roots, as in the plum, pear, breaduit, and sweet potato. It does not distinguish between the condins to be found in coffee, where the extra-axillary branch is far ove the axil, and in cotton and Castilla, where the extra-axillary nch is at the side of the axil.

Some might prefer to describe the cotton plant or the coffee tree as ving two axillary buds, and thus avoid the tendency to confuse ra-axillary position with adventitious origin, but it is evident that scientific object can be gained by applying the same name to things different as the two kinds of branches. In the strictly mathe-

matical sense only one bud could be axillary. No subsequent adventitious bud could be truly axillary. Yet to apply such a distinction to coffee would reduce it almost to an absurdity. Some of the fruit buds might be reckoned as axillary, but others closely adjacent would have to be considered as extra-axillary. The leafy branches which can be forced from these same axils by pruning would be axillary if they came out first, or extra-axillary if they followed a crop of flowers, a purely artificial distinction. Instead of attempting to establish too sharp a contrast between axillary and extra-axillary it would be better to admit a third and intermediate positional category of adaxillary branches, for those that stand close to the axil, as distinguished from extra-axillary branches that are distinctly separated from the axil.

If many buds arise simultaneously or successively from the axillary position, or as near to it as they can be placed, they might be termed coaxillary. The inflorescence branches of coffee could be described as coaxillary, and probably those of Cuscuta.[a]

In describing the functions of branches, distinctions are also to be observed. Some branches are completely vegetative and produce no flowers or inflorescences; some are completely reproductive, in the sense that they bear only floral buds. Between the two extremes a great multiplicity of intervening stages exists. Sometimes branches which normally bear fruit can be sterilized and rendered purely vegetative. In some plants all branches have equal vegetative potentialities; in others, as in coffee, cotton, and Castilla, the upright main stems are different from the lateral fruiting branches. In some plants these lateral branches can, in case of accident, become substitutes for upright stems; in others, they can furnish buds from which upright stems can arise; in still others, the lateral branches are without the power to replace the main steam.

The existence of two or more buds in or about the axil of a leaf is known, of course, in many plants and has been recognized by writers on plant morphology, but definite specializations of positions and functions have not received the attention required by the agricultural importance of such facts. As long as no difference of function has to be considered, additional buds can be considered as mere substitutes or accessories of the true axillary bud. Thus Pax[b] recognizes wh

[a] Dr. C. E. Bessey, in a paper on the adventitious inflorescence of *Cuscuta glomerata*, stated that the examination of young plants shows that the inflorescence is developed from numerous crowded adventitious buds and not by the repeated branching of axillary flowering branches, as commonly stated. Science, vol. 4, 1884, p. 342.

[b] Pax, F. Allgemeine Morphologie des Pflanzen, p. 16.

he calls "beisprossen," or accessory shoots, and subdivides these into two classes: (1) Serial shoots, if they arise one above the other, and (2) collateral shoots, if they appear side by side.

Until more general studies and classifications of methods of branching can be made it seems best to retain the ordinary designations of uprights, laterals, etc., especially in connection with plants to which these terms have already been applied. All that can be attempted at present is to indicate the varied relations between the different positions and functions of branches in the plants that have been studied.

SUMMARY OF TYPES OF BRANCHES.

The characters of the different kinds of branch individuals of cotton and the other plants with which it has been compared can be defined or briefly described as follows.

BRANCHES OF COTTON.

(1) *Axillary limbs.*—Natal axillary branches which never produce flowers, but are like the main axis of the plant in forming at each node an axillary vegetative bud and an adaxillary bud that may give rise to a vegetative or a fertile branch.

(2) *Fertile branches.*—Natal adaxillary branches which produce a flower bud on each internode, in an adaxillary position, and an axillary vegetative bud.

(2a) *Vegetative branches.*—Natal adaxillary branches which have the same form and functions as the main stem or the axillary limbs.

In varieties that have normally complete dimorphism of the branches, axillary buds give rise to vegetative branches only. Adaxillary buds can produce fertile branches or vegetative branches, except on fertile branches, where they produce flowers.

The cotton flower is always solitary, except in cases of fasciation, that are rather common in cluster varieties. Being extra-axillary, the flower is not directly subtended by a leaf or a bract, though there is a whorl of three bract leaves at the end of the simple peduncle.

BRANCHES OF CASTILLA.

(1) *Temporary branches.*—Natal axillary branches producing leaves and inflorescences; short lived and deciduous; not able to serve as main stems.

(2) *Permanent branches.*—Adventitious adaxillary or extra-axillary branches, bearing leaves and temporary branches, but no inflorescence branches; serving as permanent divisions of the main stem.

(3) *Inflorescence branches.*—Natal coaxillary branches borne on the temporary branches in clusters of four male inflorescences or two male and one female.

BRANCHES OF COFFEE.

(1) *Upright branches.*—Natal axillary branches not producing inflorescence branches; serving as equivalents of the main stem.

(2) *Lateral branches.*—Natal extra-axillary branches attached to the bases of the internodes of the main stem or of the upright branches. Lateral branches produce leaves, inflorescence branches, and secondary laterals, but are unable to replace the main stem.

(2a) *Secondary lateral branches.*—Adventitious branches arising from axillary buds of the lateral branches. They are inflorescence branches pushed into vegetative growth by severe pruning. In form and function they agree with the lateral branches.

(3) *Inflorescence branches.*—Natal and adventitious coaxillary branches borne in clusters on lateral and secondary lateral branches.

BRANCHES OF CACAO.

(1) *Upright branches.*—Probably adventitious extra-axillary branches, bearing long-petioled leaves and able to produce branches of all three kinds and to become permanent parts of the main stem.

(2) *Whorled branches.*—Natal axillary branches produced in whorls and terminating upright branches. Whorl branches bear short-petioled leaves, lateral branches, and inflorescence branches, but are unable to replace the main stem.

(2a) *Lateral branches.*—Natal axillary branches produced by whorled branches and having the same functions; not producing whorled branches or main stems.

(3) *Inflorescence branches.*—Adventitious extra-axillary branches arising from the mature wood of the main trunk and the whorled and lateral branches, without power to replace the main stem or the vegetative branches.

BRANCHES OF THE BANANA PLANT.

(1) *Sword suckers.*—True branches of the rhizome that arise from subterranean buds, develop large bulbous bases, and put forth narrow leaves when young.

(2) *Broad-leaved suckers.*—Offshoots adapted for separate vegetative propagation, arising from superficial buds and bearing broad-bladed leaves while still young.

The relations between the positions and the functions of the branches of the four woody plants are summarized as follows:

Summary of the classification of branches.

Description.	Cotton. 1.	Cotton. 2.	Cotton. 2a.	Castilla. 1.	Castilla. 2.	Coffee. 1.	Coffee. 2.	Coffee. 2a.	Cacao. 1.	Cacao. 2.
Origin:										
Natal buds	X	X	X	X		X	X			X
Adventitious buds					X			X	X	
Position:										
Axillary	X			X		X		X		X
Adaxillary		X	X		X					
Extra-axillary					X		X		X	
Reproductive function:										
Fertile		X		X			X	X	X	X
Sterile	X		X		X	X				
Vegetative function:										
Able to form main stems	X		X		X	X			X	
Not able to form main stems		X		X			X	X		X

CONCLUSIONS.

Definite dimorphism of branches exists in at least five important tropical crop plants—cotton, coffee, cacao, the Central American rubber tree (Castilla), and the banana. Each normal plant produces two kinds of branches, with regular differences of form and function.

The factor of branch dimorphism must be taken into account in the scientific study of the structure and habits of all these plants, as well as in the breeding and adaptation of varieties. Systems of cultivation and pruning must likewise be planned with reference to the habits of branching.

In each species there is a definite relation between the functions of the branches and their positions or places of origin on the internodes, but there is no general relation of position to function that applies to all the species, or even to any two of them. It is necessary to consider each plant separately in order to understand the agricultural importance of the dimorphism of the branches.

In the cotton plant the branches that arise in the axillary position have vegetative functions only, like the main stalk. The branches that produce the flowers and fruit are extra-axillary; that is, they arise at one side of the axillary branch or bud. Branches with the vegetative form and functions may replace the fruiting branches, in the extra-axillary position, but no normal fruiting branches develop in the axillary position.

The definite differentiation of the two kinds of branches represents a normal condition in all the types of cotton that have been studied

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DESCRIPTION OF PLATES.

PLATE I. Abnormal branches and involucres in the Dale variety of Egyptian cotton, where such abnormalities are especially common, though they occur also in other Egyptian varieties, as well as in Upland cotton. The figure near the upper left-hand corner of the plate represents a normal involucre of Egyptian cotton seen from the side, so that only one of the three bracts is shown. The figure at the top of the plate and that with the largest leaf immediately below represent the first stages of transformation from leaves to bracts, with the stipules enlarged, the petiole shortened, and the blade reduced in size, but retaining the texture of a normal leaf. Other figures show intermediate conditions, with the petiole suppressed, the blade more reduced and united with the stipules, and the texture becoming the same as in an ordinary involucral bract. The lower right-hand figure shows an involucre with only two bracts, the upper bract still of the intermediate form, while the lower is nearly normal, except at the base, where there is an unusually large bractlet. (Natural size.)

PLATE II. Bolls produced on short axillary branches of the Dale variety of Egyptian cotton. The long stalks of these bolls represent the fused joints of rudimentary branches, as shown by the presence of small bractlike leaves and stipules. In the figure on the left-hand side of the plate there is a bractlike organ in the position that would be occupied by a leaf on a normal fruiting branch. In the figure at the bottom of the page this organ is reduced to the size of a stipule, while on other stalks it is entirely absent. One stalk is distinctly jointed and bears two bolls in a double involucre, an example of fasciation. The right-hand figure shows an abortive fruiting branch ending in a single leaf with enlarged stipules, and a simple axillary branch bearing a normal boll. (Natural size.)

PLATE III. Part of a Maragogipe coffee tree on the Sepacuite plantation, Alta Vera Paz, Guatemala, showing three upright branches bearing numerous horizontal lateral branches. The leaves of this variety are larger, heavier, and more inclined to be crumpled than those of the ordinary Arabian coffee. (Greatly reduced.)

PLATE IV. The left-hand figure shows one internode of a very young upright and a complete internode of one of its lateral branches, projecting underneath the right-hand figure. The right-hand figure shows an older upright where pruning has forced the growth of two new upright branches, with short basal internodes, arising below the bases of the nearly horizontal lateral branches. (Natural size.)

PLATE V. A diseased condition of the lateral branches of Arabian coffee in eastern Guatemala, where the branching of the laterals has been forced by persistent pruning. (Natural size.)

PLATE VI. A young cacao tree on the Trece Aguas plantation, Alta Vera Paz, Guatemala, showing the normal method of producing branches in whorls. The whorled branches do not give rise to upright shoots, which develop from the side of the old uprights underneath the whorls. (Greatly reduced.)

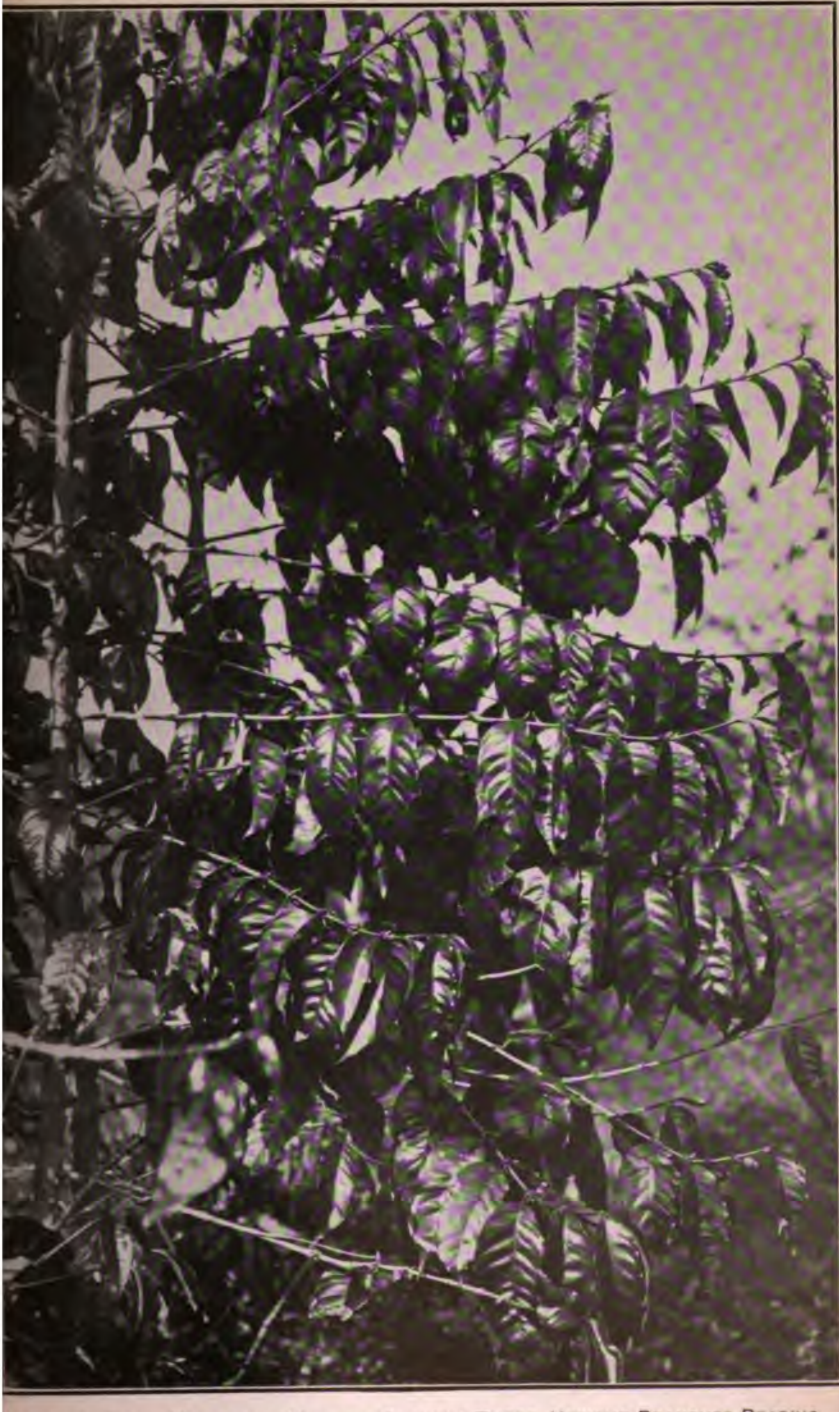
PLATE VII. FIG. 1.—Petioles of leaves from uprights of cacao. The upright branches of the cacao produce leaves with the long petioles (left-hand side of the figure). The whorled branches produce leaves with short petioles (right-hand side of the figure). (Natural size.) FIG. 2.—Section through the rhizome of a banana plant showing that sword suckers are true branches of the rhizome, unlike the broad-leaved suckers that arise from buds near the surface of the ground. (Greatly reduced.)

ABNORMAL BRANCHES AND INVOLUCRES OF EGYPTIAN COTTON.

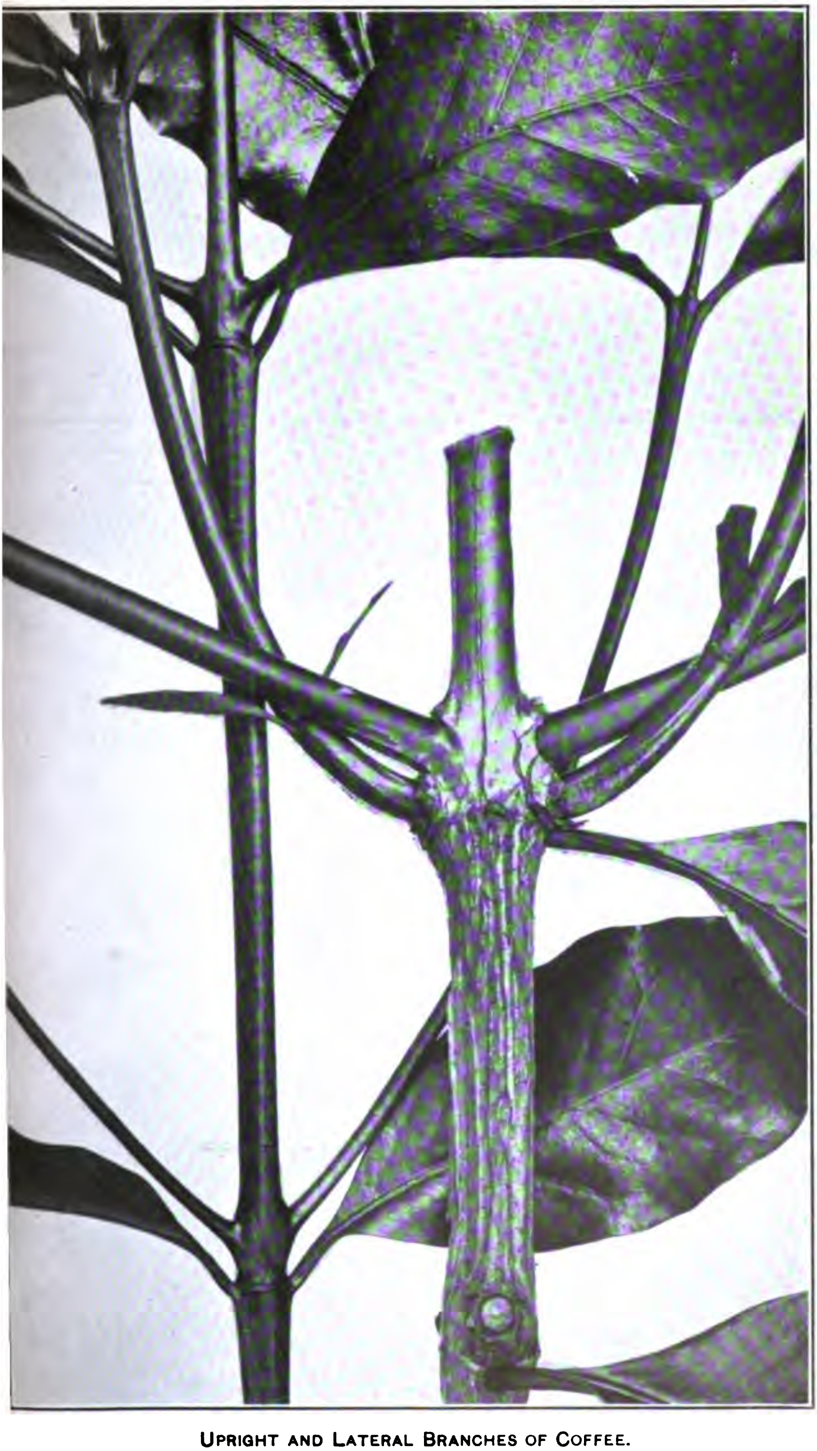
[Natural size.]

BOLLS PRODUCED ON SHORT AXILLARY BRANCHES OF EGYPTIAN COTTON.

[Natural size.]



COFFEE TREE, MARAGOGIPE VARIETY, SHOWING THREE UPRIGHT BRANCHES BEARING NUMEROUS LATERAL BRANCHES.



UPRIGHT AND LATERAL BRANCHES OF COFFEE.

[Natural size.]

ABNORMAL FORMATION OF LATERAL BRANCHES OF COFFEE.

A YOUNG CACAO TREE WITH TWO WHORLS OF BRANCHES.

FIG. 1.—PETIOLES OF LEAVES FROM UPRIGHTS AND WHORL BRANCHES OF CACAO.
[Natural size.]

FIG. 2.—SECTION THROUGH BANANA RHIZOME, SHOWING ORIGIN OF SWORD SUCKERS.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 199.

B. T. GALLOWAY, *Chief of Bureau.*

THE DETERMINATION OF THE DETERIORATION OF MAIZE, WITH INCIDENTAL REFERENCE TO PELLAGRA.

BY

O. F. BLACK AND C. L. ALSBERG,
CHEMICAL BIOLOGISTS, DRUG-PLANT, POISONOUS-PLANT, PHYSIOLOGICAL, AND FERMENTATION INVESTIGATIONS.

ISSUED DECEMBER 16, 1910.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1910.

BUREAU OF PLANT INDUSTRY.

Chief of Bureau, Beverly T. Galloway.
Assistant Chief of Bureau, G. Harold Powell.
Editor, J. E. Rockwell.
Chief Clerk, James E. Jones.

Drug-Plant, Poisonous-Plant, Physiological, and Fermentation Investigations.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., August 20, 1910.

SIR: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 199 of the series of this Bureau the accompanying manuscript entitled "The Determination of the Deterioration of Maize, with Incidental Reference to Pellagra," by Mr. Otis F. Black and Dr. Carl L. Alsberg, Chemical Biologists, which has been submitted for publication by Dr. Rodney H. True, Physiologist in Charge of Drug-Plant, Poisonous-Plant, Physiological, and Fermentation Investigations, of the Bureau of Plant Industry.

As a necessary preliminary step in the investigation of the alleged relation between spoiled corn and pellagra the authors of this paper have made a critical study of the methods of detecting products of deterioration in corn and corn meal. The recent recognition of pellagra in the United States has emphasized the fact that there is a lack of such information in a form available for English readers and has brought about a considerable demand for it. The accompanying paper deals critically with the value of methods employed in foreign countries and contains experimental data bearing upon their application to conditions in this country. The work constitutes a first step in the study of the constituents present in corn and the possible production of toxic substances by deterioration.

Respectfully,

G. H. POWELL,
Acting Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE DETERMINATION OF THE DETERIORATION OF MAIZE, WITH INCIDENTAL REFERENCE TO PELLAGRA.

INTRODUCTION.

The recent recognition of cases of pellagra in this country, principally in the Southern States, and the supposed connection of the disease with the consumption of unsound corn[a] have called attention to the lack of methods by which to test the fitness of corn and corn meal for human consumption. There is every reason to believe that sound corn is a most wholesome food. Whether corn that has been heated, fermented, or molded is equally safe is another question. That it is unsafe and the cause of pellagra is so firmly believed in Italy and the Austrian Province of the Tyrol that the Governments of these countries have enacted stringent laws regulating the quality of corn and corn meal which may be sold or imported.[b] The possibility that spoiled corn may possess poisonous qualities seems to have passed unnoticed in this country.

Indeed, it is found that with the exception of such work as that of Osborne[c] and others upon the proteins, little work has been done

[a] The term "corn" is a general one, usually applied to the chief cereal crop of a country. It is therefore not necessarily applied everywhere to the same cereal. Thus, in England, it is applied to wheat, and in the United States to maize (Indian corn). The terms Indian corn, maize, and corn will be used interchangeably in this paper.

[b] Bollettino Ufficiale del Ministero d'Agricoltura, Industria, e Commercio, Rome, new series, vol. 4, no. 4, October, 1902, pp. 663–666.

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[c] Chittenden, R. H., and Osborne, T. B. A Study of the Proteids of the Corn or Maize Kernel. American Chemical Journal, vol. 13, 1891, pp. 453 and 529, and vol. 14, 1892, p. 20.

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Osborne, T. B., and Harris, I. F. The Specific Rotation of Some Vegetable Proteins. Journal of the American Chemical Society, vol. 25, 1903, p. 842.

Osborne, T. B., and Clapp, S. H. Hydrolysis of the Proteins of Maize. American Journal of Physiology, vol. 20, 1908, p. 477.

Osborne, T. B., and Harris, I. F. Nitrogen in Protein Bodies. Journal of the American Chemical Society, vol. 25, 1903, p. 323.

upon the chemistry of corn. Most investigators have content themselves with the determination of protein, carbohydrate, fat, a ash. Some have also studied certain of the simpler constants these groups of substances. The attempt to disentangle the mixtu of complex substances of which the corn seed, like any other livi thing, is composed has hardly begun. The investigators of southe Europe who had in the alleged connection between pellagra and co a great incentive to undertake this work have not done so. I southern Europe, however, much attention has been paid to th toxicity of spoiled corn, if not to the chemistry, and the relevan literature is very large.

It is not the object of this paper to discuss the question wheth pellagra is due to eating spoiled maize. The position taken is th whatever may ultimately prove to be the cause of pellagra the co sumption of spoiled maize is undesirable. Even if spoiled mai should ultimately be proved to have nothing whatever to do wit pellagra, its consumption would still remain decidedly objectionabl for the same reasons that would apply to any other form of spoile food. Here the economist, the hygienist, and the agriculturist mee upon common ground. If the hygienist should condemn corn a corn, it would react upon the agriculturist by narrowing the marke for the country's chief crop. It is therefore of the utmost impor tance to the agriculturist that the deterioration of corn be inves tigated in all of its bearings in order that he may learn to avoid the causes of the spoiling of corn and that the consumption of spoiled corn by man may be limited. Ultimately this will be to the interest of all classes, whether growers, middlemen, or consumers. To bring about this result it must be possible to detect deterioration in corn. This is not always easy, even for unground corn. By drying moldy corn, moving it about in an elevator,[a] thereby polishing off the mold which covers the individual kernels, and by mixing it with sound corn it is possible to render the detection of spoiled corn difficult. When it is a question of meal made from spoiled corn or meal made from sound corn but spoiled after milling, the matter becomes even more difficult. In such cases special methods are necessary. Some methods for this purpose have been devised in Italy[b] and Austria.[c]

As far as known no work along these lines has been published in this country or, indeed, in the English language. To fill this gap by

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[a] This process is called "running" and is a common treatment, as it aerates and thus helps to dry the corn.

[b] Antonini, G. Atti del Terzo Congresso Pellagralogico Italiano, September, 1906. Udine, 1907, p. 70.

[c] Schindler, J. Anleitung zur Beurteilung des Maises und seiner Mahlprodukte mit Rücksicht auf ihre Eignung als Nahrungsmittel. Verfaszt über Veranlassung der königlich kaiserlichen Statthalterei in Innsbruck. Innsbruck, 1909.

critical study of the methods used in Europe and where possible to add to them is the object of the present paper. It is hoped to give criteria which will enable manufacturers of human food, public health officers, the directors of hospitals, of insane asylums, of penal institutions, and others to judge of the quality of corn and corn meal.

In Italy and Austria, where the Governments carefully control the quality of corn, suspected corn is examined by skilled government experts. In this country, where the examinations will be made in most cases only upon the initiative of private individuals, many of the tests applied abroad would often be of little service because they require a considerable degree of chemical or bacteriological skill. What seems to be needed in this country is some adequate test of so simple a character that it may be applied by the manufacturer, the health officer, or the consumer in determining whether products or purchases are fit for human food.

Such a test is thought by the writers to be the determination of the acidity of corn. This is a well-known test in both Italy and Austria, where much stress is laid on its importance. In this work it has been found the most reliable means of distinguishing good from bad corn. All corn is somewhat acid, not necessarily to the taste, but to chemical reagents. Since the spoiling of corn is due to fermentation processes in which acids are among the products, the extent to which this deterioration has progressed can be measured by the amount of acid present. It becomes necessary then only to fix a standard of acidity above which corn should be considered unfit for food.

It is desired at this point to avoid creating a misunderstanding. It is desired most carefully to avoid producing the impression that all fermented, heated, moldy, or otherwise spoiled corn is necessarily dangerous to man. This would hardly be in accord with the facts. It is, however, quite generally believed by the majority of investigators that much of this sort of corn is injurious. As long as no more definite information exists it seems the sane and conservative course to bar as far as possible damaged corn from human consumption.

The remainder of this paper will be divided into two parts, the first giving a description of the method of determining the acidity of corn and the second and longer part designed for the use of those more or less skilled in chemical manipulations and giving a critical presentation of various methods of examination.

PART I.—METHOD OF DETERMINING THE ACIDITY OF CORN.

Apparatus necessary.

One graduated burette.

One or more 50 cubic centimeter graduated glass flasks fitted with ground-glass stoppers.

One or more 5-inch glass funnels.

One filter stand or some appliance for holding funnel while filtering.

Three-inch filter papers, preferably folded filters.

One or more 25 cubic centimeter graduated glass cylinders.

If whole corn is to be examined, a mill is necessary—a drug or coffee mill will do.[a]

Reagents necessary.

Neutral alcohol. Such alcohol may be obtained from dealers in fine chemicals. If no neutral alcohol is at hand, it may be readily prepared by the distillation of the ordinary 95 per cent alcohol with the addition of unslaked lime. A few lumps of quicklime are put in a still or retort of copper or iron; the alcohol is poured in and the still connected with a water-cooled condenser. The so-called Liebig condenser is good for this purpose. The connections may be made with suitably bent glass tubes and cork or rubber stoppers. A receiving vessel is placed under the open end of the condenser to catch the alcohol. The still or retort is then heated with a nonluminous flame till the greater part of the alcohol has boiled over. All the alcohol can not be recovered because of the danger of burning the still. An ordinary kerosene can may be used as a still, the spout of the can being connected with the condenser. If no metal vessel suitable for use as a still is at hand, a glass distilling flask may be secured from a dealer in chemical apparatus. It is best to use those made of Jena glass. The glass must not be heated directly, but must be heated over a water bath in the manner of a double boiler. To accomplish this it is immersed up to the beginning of its neck in some sort of kettle filled with water. The heat is then applied to the kettle. The flask is touched only by the boiling water. Care must be taken that the flask does not break, for then there is danger of setting the alcohol on fire. A fire of this kind is best put out by smothering it with sand, a small keg of which should be kept handy.

A solution of phenolphthalein as indicator.

Distilled water.

Twentieth normal caustic alkali (NaOH or KOH). This, too, may be purchased from dealers in fine chemicals. Only small quantities should be purchased or made at a time, as it deteriorates in a month or two, even if tightly stoppered, when it should be replaced with fresh solution.

Procedure.

If the sample to be tested is whole corn it must first be ground until all of it can be passed through the 20-mesh sieve. For this purpose a fair sample should be made, taking it from different parts of the lot—the bottom as well as the top. The sample should not be too small. It should consist of at least 500 kernels. If it is meal no further grinding is necessary, but the sample should be a mixed one, consisting of portions taken from different parts of the sack. Ten grams of the thoroughly mixed

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[a] A satisfactory mill is depicted by C. S. Scofield, in "The Commercial Grading of Corn," Bulletin 41, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1903, pl. 2. For whole corn a sieve made of bolting cloth with 20 meshes to the inch will also be required. If meal only is to be examined, both the mill and the sieve may be dispensed with.

sample are weighed out and transferred to a 50 cubic centimeter graduated flask fitted with a ground-glass stopper. The flask is then filled to the 50 c. c. mark with neutral alcohol of a strength of 85 per cent by volume. After the addition of the alcohol the flasks are allowed to stand for twenty-four hours at room temperature with an occasional shaking. At the end of that period a dry filter paper is placed in the glass funnel and the stem of the funnel brought over the 25 cubic centimeter cylinder. Then the clear liquid in the 50 c. c. graduated glass flask is poured into the dry filter and collected in the graduated cylinder. When this is filled to the 25 c. c. mark, the contents are transferred to a small flask or beaker.

The alcohol adherent to the inside of the cylinder is rinsed into the beaker with a little distilled water. From 100 to 150 c. c. of distilled water and a few drops of the phenolphthalein solution are then added to the liquid. The burette, which must be clean and dry, is filled to the zero mark with the twentieth normal alkali solution and the alkali allowed to run drop by drop into the beaker, the contents of which are continually stirred, until the first permanent pale-pink coloration of the whole liquid appears. The number of cubic centimeters run into the beaker is then read off on the burette. The number of cubic centimeters twentieth normal alkali solution used, multiplied by 10, gives the acidity of 1,000 grams (1 kilogram) of corn in terms of cubic centimeters, normal alkali. The results given below under the head of acidity are calculated on this basis. It is to be noted that on the addition of the 100 to 150 c. c. of distilled water to the 25 c. c. of alcoholic extract, some zein (the alcohol-soluble protein found in corn) is precipitated, giving a cloudy appearance to the solution; but this cloudy appearance wholly or partly disappears on the addition of alkali from the burette, so that the pink coloration which marks the end point of the operation is quite obvious.

Having determined the acidity of the corn sample in terms of cubic centimeters of normal alkali, the question that next arises is whether the acidity found is that of good corn or is greater than it should be. As will be seen by reference to Part II of this paper, it has been found that the acidity number of sound corn ranges from 13 to 25; i. e., it required from 13 to 25 cubic centimeters of normal alkali to neutralize the extract from 1,000 grams (1 kilogram) of sound corn. It is necessary, however, to allow for a certain amount of variation in the corn, so that 30 cubic centimeters may be fixed upon as a safe limit. This is the limit adopted by Schindler,[a] the Austrian authority. The writers decided to calculate the acidity on a basis of 1 kilogram (2.2 pounds) to bring the figures into conformity with Fuller's scale, now very generally employed by bacteriologists.

Carried out according to this method, the determination of the acidity of corn is easily made. Any physician ought to be able to carry it out accurately, for it is far easier than to determine the acidity of gastric juice, a determination with which every physician is familiar. Graduates in pharmacy will find no trouble in performing it and it is suggested that manufacturers of human food from maize and other persons who do not wish to bother with these determinations might have them done by the local pharmacist.

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[a] Op. cit., p. 32. The writers are indebted to the article by Schindler for many valuable data incorporated in this paper.

Inasmuch as pellagra is peculiarly likely to appear in insane asylums, hospitals, and penal institutions, and inasmuch as such institutions are often compelled by law to purchase their supplies from the lowest bidder, it may be well before proceeding further to formulate rules which will enable their superintendents to specify a high grade of corn. It is advised that those purchasing corn meal for food purposes should insist that it meet the following three requirements:

(1) It shall not contain more than 12 per cent of moisture.

(2) It shall be made from degerminated corn.

(3) It shall not have a greater acidity than 30, determined by the method already detailed.

The first requirement is advised because even the best corn will spoil if it contains much moisture unless it is stored in a very cold and dry place; the second is advised because the germ, or embryo, with its high protein and fat content, is the chief point of attack by micro-organisms; the third is advised because the acidity is the simplest index of deterioration through the action of micro-organisms. All three will be discussed in detail in the second part of this paper.

PART II.—METHODS OF EXAMINING CORN.

CONDITIONS TO BE CONSIDERED.

In the examination of corn for deterioration two conditions must be considered: (1) The detection in otherwise sound corn of factors which render it liable to spoil at some future time, and (2) the detection of actual deterioration.

The detection of the former condition is very simple and consists of a determination of the moisture content, since excessive moisture content is believed to be the chief factor in causing corn to spoil.[a] Schindler[b] believes that whole corn to be safe should not contain when stored more than from 13 to 15 per cent of moisture. It is probable that in this country 15 per cent is too high a limit.

Thoroughly air-dried corn contains about 12 per cent.[c] Corn with a much greater moisture content has either been harvested too soon, as is often necessary in cold, wet seasons, or it was shelled without adequate curing on the cob. Storage under conditions which do not

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[a] Scofield, C. S., op. cit., p. 20.

Duvel, J. W. T. The Deterioration of Corn in Storage. Circular 43, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1909.

Shanahan, J. D., Leighty, C. E., and Boerner, E. G. American Export Corn (Maize) in Europe. Circular 55, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1910.

[b] Op. cit., p. 7.

[c] Shanahan, Leighty, and Boerner, op. cit., p. 22.

protect it from the weather may, of course, increase the moisture content. Such corn is particularly liable, given a favorable opportunity, to heat and ferment.

For both whole corn and meal the drying test is the only reliable method of determining moisture and should always be applied in doubtful cases. However, for meal a different limit is required than for whole corn, since, given an equal moisture content, meal spoils more readily than whole corn. Schindler believes that 13½ per cent is the limit for meal; and that under ordinary conditions corn with a moisture content of 15 per cent will yield meal with a moisture content of 13½ per cent.[a] For this country both limits are probably too high. The actual method of carrying out these moisture determinations is so well known that it need not be described here. For the details the reader is referred to the paper of Brown and Duvel.[b]

It must, however, be pointed out that moist corn which is otherwise sound ought not to be condemned. Curing prior to storage should be insisted upon. Corn will then be in very excellent condition, fit for any use. It is perhaps worth while to point out in this connection that if growers and handlers of corn could be induced to dry corn adequately, this would result in a great addition to the wealth of the country, irrespective of any possible danger to the public health from the consumption of spoiled corn. This saving would be in at least three directions: (1) Much less good corn would deteriorate in transit and storage; (2) millions of gallons of water in the form of undesirable moisture in corn are transported annually from the corn belt; the cost of transportation of this water might be saved; (3) the germ in the corn kernel is a living thing. As long as it is not very dry it respires and gives off carbonic acid and water. Like all living things it uses up food in the process of respiration. The food it consumes is the material stored in the endosperm. It is clear that the more food the embryo respires away the less will be left for man. Now, it has been proved that the drier corn is the less it respires, until, as it approaches absolute dryness, respiration becomes minimal.[c] It is evident, then, that moist corn must lose in food value in the course of time more than dry corn. It is impossible at present to say exactly what this loss amounts to, because data on the variation of respiration with moisture content do not exist. It is probably not great enough to affect seriously any single owner of corn, but it is quite probable that if it were possible to cal-

[a] Op. cit., p. 24.

[b] Brown, Edgar, and Duvel, J. W. T. A Quick Method for the Determination of Moisture in Grain. Bulletin 41, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1907.

[c] White, Jean. The Ferments and Latent Life of Resting Seeds. Proceedings of the Royal Society, vol. B 81, p. 417.

culate it for the country as a whole it would amount to a very large sum indeed.

The method of detecting actual deterioration of whole corn differs from that for corn meal. The methods for each will therefore be considered separately.

EXAMINATION OF WHOLE CORN BY INSPECTION.

Good corn must be sufficiently dry, as has been discussed above. It must be mature. It should not contain many cracked, rifted, or broken kernels. The hull protects the kernel from the attacks of bacteria and fungi. If the hull is burst or the kernel broken, the grain is likely to become moldy. The rifts may be due to imperfect artificial drying or to the careless shelling of inadequately cured corn. However, care must be taken not to confuse rifts of this type with the small ones, which are entirely internal, due to shrinking of the horny layer. The latter do not penetrate the hull, and therefore are unobjectionable, because they do not give access to micro-organisms. They are due to artificial drying at too high a temperature or more frequently to drying very moist corn too rapidly. When grain is observed to be covered with white powder, it has probably been damaged by insects, the granary weevil (*Calandra granaria* L.), the rice weevil (*Calandra oryza* L.), the wolf moth (*Tinea granella* L.), the Angoumois grain moth (*Sitotroga cerealella* Ol.), or other insects.[a] Injury by insects is of importance for the same reason that a burst hull is. By piercing the hulls insects open the way for fungi. Good corn should not contain many moldy or bad kernels. Schindler[b] believes that a content of more than 5 per cent of them should not be allowed. This limit is probably a good one when the grain is examined in the laboratory in the careful way advised in this paper. When, however, the grain is examined in the usual way by the grain inspector, only the more seriously damaged kernels would be apt to be noticed, so that under these circumstances this limit is probably too high. Under these conditions 2 to 2.5 per cent of moldy or cob-rotten kernels is a safer limit.[c]

The mold or bacterial growth may be either superficial, the fracture surfaces of broken kernels being attacked with particular frequency, or it may be in the interior when this has become accessible as the result of cracks, rifts, or injury by insects. It is then almost always the embryo which is the site of the growth of micro-organisms, presumably because it presents the most favorable soil. Sometimes

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[a] For details the reader is referred to "Some Insects Injurious to Stored Grain," by F. H. Chittenden, Farmers' Bulletin 45, U. S. Dept. of Agriculture, 1897.

[b] Op. cit., p. 15.

[c] See Shanahan, Leighty, and Boerner, op. cit., p. 42.

this growth is evident only as a faint, bluish-gray spot, barely perceptible through the hull covering the groove in which the embryo lies. It is easily overlooked by the inexperienced, and it is therefore wise to trim off with a small sharp-pointed knife the hull covering the groove of suspicious-looking kernels, when the sound or decayed condition of the embryo may be recognized by anyone. If the decay is more advanced, the embryo may appear distinctly bluish-green, and when the hull is removed it will be seen that the embryo has been more or less completely replaced by a bluish-green powder, the spores of the fungi. Such grain is often known as blue or black eyed corn. In extreme cases the entire surface of the kernels may be covered with this bluish-gray or greenish mold powder. This discoloration seems to be caused by members of the genus of molds known as Penicillium. Other molds will produce other shades of color. One sample of corn examined in the course of the present investigation was covered with a bronze-colored powder. Dr. Erwin F. Smith, of the Bureau of Plant Industry, who examined it, identified it as spores of *Aspergillus fumigatus*. Doctor Duvel in a personal communication states that he has not infrequently encountered corn spoiled in this way. It is stated that sometimes the embryo is colored reddish by *Micrococcus prodigiosus*. In deciding whether any given kernel is moldy or not, one must be careful not to be misled by the color of the tip cap, which is often naturally of a darker color than the rest of the kernel.

Corn which has heated in bulk may show the result of bacterial action rather than that of molds. It is often more or less irregularly discolored, showing lighter and darker blotches and streaks, more especially in the region of the embryo and toward the tip. These spots are colonies of micro-organisms which are not merely confined to the surface, but also invade the interior of the kernel. In extreme cases the heat developed may be so great that the corn becomes brown or black and charred.

Good corn, finally, should have the fragrance characteristic of good meal. Spoiled corn has sometimes a musty or a sour odor, which may be intensified by warming it slightly in some way, such as holding it for a few moments in the closed hand or by blowing the breath upon it. Good corn should have the characteristic, slightly sweet taste of good meal. Spoiled corn may lack this characteristic taste and is often bitter.

These are the external criteria by which corn may be judged in regard to its fitness for human food. Their practical application in examining corn will now be considered. The first point is to obtain a fair sample. As already indicated, samples should be taken from various parts of the mass of corn; from the top, the bottom, and

different levels between, and from the sides. The number of samples to be taken will depend upon the quantity of corn. Whether the odor be musty, or sour, or like the interior of a silo is noted as each sample is taken. The general appearance of each sample must be observed, for in dealing with large masses of grain different conditions may be met with in different regions of the mass. If this proves to be the case, the different samples are best examined separately. Ordinarily, however, the various samples are thoroughly mixed and the sample for examination taken from the mixture at several different points. The moisture content is determined accurately.

The pile is then spread out in a thin layer and the corn examined to see whether it is of characteristic bright, shiny appearance or whether the kernels are dull, blotched, discolored, with colored embryo indicative of heating and fermentation, or whether they are pale and shriveled, sometimes indicative of immaturity. The presence of many rifted, broken, or cracked kernels, or of much foreign matter, such as weed seeds or such débris as pieces of cob, is noted. While the latter are not in themselves necessarily harmful, they are hotbeds of molds which are liable under favorable conditions to infect the sound kernels.[a] A large number of kernels are next examined, one by one, for insect injury, and with a sharp-pointed knife the hull is removed from the embryo to show whether its condition is good. By this superficial examination an idea is obtained of the number of spoiled kernels present, which if excessive must be determined.

To do this, small numbers of kernels from different parts of the sample as it lies spread out thin on the white paper are taken until there are at least 500 kernels. These are spread out on white paper and each kernel examined individually, the good being put in one pile and the bad in another. When all have been examined each pile is weighed and the percentage of spoiled kernels computed. This should not exceed 5 per cent.[b]

BIOLOGICAL EXAMINATION.

The biological examination of corn was first proposed by Sclavo.[c] It is based on the fact that the chief point of attack for microorganisms is the embryo, or germ. If the action of the microorganisms is enough to kill the germ, the kernel loses its power to germinate. The best seed corn germinates as high as 97 per cent

[a] See Shanahan, Leighty, and Boerner, op. cit., p. 22.

[b] See p. 14.

[c] Sclavo, Vincenzo. Gazzetta Medica di Torino, vol. 52, October 24, 1901, p. 853.

and over.[a] The method of determining germination is very simple. For details the reader is referred to the paper of Hartley.[a] It is only necessary to add that at least 100 kernels should be tested. No tests were made upon commercial grades of corn in the work here reported, and therefore a standard can not be fixed. The Italian Government[b] has fixed as a limit a germinating power of 80 per cent, while Ori [c] protests that this limit is too low. He advocates a limit of 90 per cent. This test, simple and excellent though it be, is not universally applicable. If perfectly sound but moist grain be dried at too high a temperature, the germinating power may be destroyed though the grain be of excellent quality. This is not likely to happen in the United States, for the driers do not ordinarily work at a sufficiently high temperature. Indeed, it is stated in a personal communication by Doctor Duvel, of the Office of Grain Standardization of the Bureau of Plant Industry, that he has known moist corn to gain in germinating power by being passed through a drier.[d] Furthermore, if corn of very high germinating power were mixed with spoiled corn of very low germinating power, this admixture might escape detection though it exceeded 5 per cent, because the germinating power might still exceed 90 per cent.

It may be well, apropos of the dependence of the biological test upon the sound condition of the embryo, or germ, to point out the importance of the germ in determining the quality of the manufactured meal. As already indicated, the germ is the chief site of attack by micro-organisms. By removing the germ from corn that has not been too badly spoiled the greater part of the micro-organisms and their products will be removed. If the statements of European investigators concerning the toxicity of spoiled corn are to be believed, it follows that degerminated spoiled corn is less toxic than it was before the removal of the germ. Indeed, it has been shown that in the process of milling the more unwholesome material goes into the poorer grades of meal, which contain the starchy part of the endosperm lying next to the germ, and also into the germ,[e] which in this country is used for the manufacture of corn oil and stock feed. Moreover, the high oil content of the germ renders meal from whole corn less desirable than that from degerminated corn, since

[a] See Hartley, C. P., "The Production of Good Seed Corn," Farmers' Bulletin 229, U. S. Dept. of Agriculture, 1905, p. 19.

[b] Rivista Pellagrologica Italiana, vol. 5, p. 122.

[c] Ori, A. La Diagnosi delle Alterazioni del Maiz in Chicchi ed in Farina. Rivista Critica de Clinica Medica, 1906, p. 165.

[d] See Webber, H. J., in appendix (p. 22) to paper of C. P. Hartley previously cited.

[e] Balp, S. Venticinque Anni di Lotto contra la Pellagra (1881–1906), Biella, 1908.

Table III is a presentation of the acidity of a number of samples of seed corn of various strains from various parts of the country. Mr. C. P. Hartley, Physiologist in Charge of Corn Investigations, Bureau of Plant Industry, furnished most of the samples. The determinations were made in February, 1910, except No. 10, which was made in December, 1909. The samples contain specimens of the crop of 1909 and 1908. It is seen that the acidity ranges from 13 to 24 c. c. and that the 1908 corn is no more acid than that of 1909. No. 51 is from the same ears as No. 50; it differs from the latter in consisting only of the smaller kernels from the tips of the ears. No. 28 is corn specially bred for low-protein content, while No. 29 was specially bred for high-protein content. No. 40 is corn prematurely ripe, such as is often produced in years with exceptionally warm and dry autumns.

TABLE III.—*Acidity and moisture of selected samples of high-grade corn from various sections of the United States.*

No. of sample.	Name of variety.	Ash.	Acidity.	Moisture.	Locality.
		Per cent.	*c. c.*	*Per cent.*	
1	Sturgis Hybrid, 1908	1.59	18.0	7.60	Connecticut.
2	White North Dakota Flint, 1908	1.22	18.0	8.11	North Dakota.
3	Barnwell White, 1908	1.26	17.5	7.93	South Carolina.
4	Marlboro Prolific, 1908	1.25	13.0	7.71	Do.
5	Boone County White, 1908	1.29	15.0	7.47	Tennessee.
6	Huffman, 1908	1.42	13.0	8.25	Do.
7	Strawberry, 1909	1.55	18.0	7.56	Texas.
8	Marlboro Prolific, 1909	1.38	15.0	10.09	South Carolina.
9	Boone County White, 1909	1.23	13.0	7.81	Tennessee.
10	Whole corn, selected ears, 1909	1.18	23.0	10.00	Maryland.
28	Low-protein corn		16.5		Illinois.
29	High-protein corn		19.5		Do.
40	Prematurely ripe white corn		24.0		District of Columbia.
50	Whole seed corn		16.2		Virginia.
51	Corn tips		16.5		Do.

Small samples of meal were purchased in the open market in Washington, D. C., Summerville, S. C., Boston, New York, and Chicago. In all the cities but Washington the samples were purchased from little stores in the parts of town where poor people trade. In Washington the samples were purchased in different parts of the city, in the fashionable residential section as well as the poor quarters. The results are presented in Table IV. This table also includes meal No. 11, ground in the laboratory from corn which had been allowed to spoil in the bin of a grain elevator at Baltimore during the course of an experiment conducted by Doctor Duvel,[a] who very kindly furnished not only this sample but also many others. Doctor Duvel and Mr. Shanahan, the Crop Technologist in Charge of Grain Standardization, Bureau of Plant Industry, gave much help and

[a] See Duvel, J. W. T., "The Deterioration of Corn in Storage," Circular 43, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1909.

lvice. Nos. 12 and 14 were from two institutions in which cases of ellagra had occurred. It will be seen that a considerable number f samples have too high an acidity.

ABLE IV.—*Acidity of samples of commercial corn meal purchased in several cities in the United States.*

No. of sample.	Variety.	Water.	Ash.	Acidity.	Locality.
		Per cent.	*Per cent.*	*c. c.*	
11	Whole corn, spoiled	9.5	1.50	37	Baltimore.
12	White meal	10.0	1.04	78	Illinois.
14	....do	10.7	2.90	60	Arkansas.
15	....do	10.0	1.47	33	Washington, D. C.
16	Yellow meal	10.8	.33	23	Do.
17	White meal	10.4	1.03	39	Do.
18	Yellow meal	10.0±	.22	17	Do.
19	White meal	10.0±	1.08	29	Do.
20	....do	10.0±	1.06	29	Do.
21	....do	10.0±	1.30	41	Do.
22	....do	10.0±	1.05		Do.
23	....do	10.0±	1.26	37	Do.
24	....do	10.0±	.98	24	Do.
30	....do			23	Summerville, S. C.
31	....do			28	Do.
32	....do			16	Do.
33	....do			30	Do.
34	Yellow meal			37	Boston.
35	....do			37	Do.
36	....do			35	Do.
37	....do			19	Chicago.
38	....do			20	Do.
39	....do			23	Do.
41	....do			19	New York.
42	....do			23	Do.
43	....do			40	Do.
44	....do			21	Do.
45	....do			18	Do.
46	....do			16	Do.
47	....do			13	Do.
48	....do			29	Do.
49	....do			17	Do.

The mother substances of the acid formed have not yet been finally determined, but some of the analytical results give indications as to their nature.

TABLE V.—*Analyses of different portions of a carload of damaged corn.*

Sample.	Water.	Ash in dry material.	Acidity.	Fat in dry material.	Nitrogen in dry material.
	Per cent.	*Per cent.*	*c. c.*	*Per cent.*	*Per cent.*
No. 25, top	11.53	1.51	95.0	4.25	2.53
No. 26, 2 inches from top	8.33	1.41	73.0	3.94	1.86
No. 27, 6 inches from top	8.06	1.24	64.0	3.87	1.29
Normal corn	[a] 10.75	[a] 1.50	[b] (15–30)	[a] 4.2	[a] 1.60

[a] Wiley. [b] Schindler.

Table V gives analyses of three samples of corn taken from the same car while undergoing heating. No. 25 was taken at the surface, No. 26 was taken 2 inches below, and No. 27 was taken 6 inches below the surface. Appended to Table V is an analysis of average corn

published by Wiley.[a] No. 25 had sprouted but had been killed before growth had advanced beyond a beginning. It was covered with blue-green mold and had a very musty odor. To the eye, nose, and tongue it was one of the worst specimens handled. No. 26 was less moldy but still had a musty odor blended with a sour smell. No. 27 was characteristic of heated corn and had a very sour smell.

These differences may be due to the fact that on the surface corn the aerobic fungi flourished, while down in the interior the anaerobic ones developed. It must, however, be remembered that scientists are at variance as to the mechanism which causes the heating of vegetable material when it is bulked. There are three views. Some believe that the heating is due in the main to bacterial action.[b] Others believe that it is due to the action of oxidizing enzymes.[c] Finally, Boekhout and Ott de Vries[d] have shown that oxidation can take place by simple catalysis under conditions which exclude the intervention of micro-organisms as well as enzymes. No similar studies have been made upon corn or, indeed, upon any other seed, so that as yet it can only be surmised what takes place in these cases. It will be seen that No. 25 with the highest acidity has also the highest fat and nitrogen content. This is not due to an absolute increase in these substances but to a relative one caused by the disappearance of some other substance which can not be anything other than carbohydrate. Here is evidence, then, that carbohydrate, in this single case at any rate, furnished the material from which acid was formed. This is in accord with what is known in general about fermentation and with the observations of Italian authors.[e]

It is, of course, probable that the fat is more or less saponified, thereby becoming rancid, and that the fatty acids formed contribute to the acidity. This point is being investigated by the writers. It is particularly important in the light of recent researches upon the toxicity of unsaturated fatty acids.[f]

The figures of Table V are perhaps not typical of all cases of spoiling. It is even probable that under different conditions quite a

[a] Wiley, H. W. Composition of Maize. Bulletin 50, Bureau of Chemistry, U. S. Dept. of Agriculture.

[b] Miehe, H. Die Selbsterhitzung des Heus. Jena, 1907.

[c] Loew, O. Curing and Fermentation of Cigar-Leaf Tobacco. Report 59, U. S. Dept. of Agriculture, 1899.

[d] Boekhout, F. W. J., and Ott de Vries, J. J. Über Tabaksfermentation. Centralblatt für Bakteriologie, Parasitenkunde und Infektionskrankheiten, vol. 24, pt. 2, p. 496.

[e] Gosio, B. Ricerche Batteriologiche e Chimiche sulle Alterazioni del Mais. Contributo all' Etiologia della Pellagra. (Memoria 2 a) Rivista d'Igiene e Sanità Pubblica, vol. 7, 1896, p. 825.

[f] Faust, E. S. Über chronische Ölsäurevergiftung. Archiv für Experimentelle Pathologie und Pharmakologie. Supplement, 1908, p. 171.

fferent state of affairs may be found. These figures are to be garded only as a single instance until more samples of a similar ature are analyzed.

The writers have begun investigating the nature of the substances hich render the extracts acid. This seemed important because ein might be one of them. Zein is one of the chief proteins of the ndosperm. It probably does not occur at all in the embryo before ermination.[a] It is soluble in moderately strong alcohol, insoluble 1 dilute and absolute alcohol, and behaves somewhat like an acid in ombining with a certain amount of alkali. Its solubility in alcohol asures its being present in the extracts. As it is more soluble in ot than in cold alcohol it seems possible that differences in the emperature of the room during extraction might cause more or ess of it to pass into solution and thus affect the results. It was herefore important to determine whether the increased acidity of poiled corn was dependent to any considerable degree upon the zein. To settle this point both the acidity and the nitrogen content of the xtract of both spoiled and sound corn was determined. The nitrogen content would give an index of the amount of zein that had gone into solution. The figures obtained are given in Table VI. Under the heading "Kjeldahl nitrogen" is given the amount of nitrogen, as determined by the Kjeldahl method in the amount of alcoholic extract used for the titration (25 c.c.). The same extract used in the titrations was used for the nitrogen determinations. Hence the acidity and the nitrogen figures are quite comparable.

TABLE VI.—*Relation between the total nitrogen and the alcoholic extract of corn meal.*

No. of sample.	Kjeldahl nitrogen.	Acidity.
	Grams.	*c. c.*
14	0.0139	60.0
10	.0297	23.0
25	.0099	95.0
26	.0140	73.0
27	.0105	64.0
28	.0081	16.5
29	.040	19.5

It will be seen that the very acid extract from the spoiled corn contains less nitrogen and therefore less zein than the extract from good corn except sample No. 28. Now No. 28 is a low-protein corn. Its acidity is low and the small amount of nitrogen in the extract seems to depend not on the acidity but upon the low-protein content of the grain. This assumption gains in probability by the figures obtained

[a] Soave, M. L'Azoto della Zeina in Relazione all' Azoto Totale e all' Azoto delle Altre Sostanze Proteiche nel Mais. Le Stazioni Sperimentali Agrarie Italiane, vol. 40, p. 193.

with No. 29, which is a high-protein corn. This gives the highest nitrogen figure and yet differs in acidity by only 3 c. c. from No. 28, which gives the lowest nitrogen figure. This difference in the behavior of low and high nitrogen corn is very suggestive from a number of points of view. From the present standpoint it is of interest that although the amount of nitrogen in the alcoholic extract probably influences to a slight degree the acidity values obtained under the present conditions it can not possibly influence them enough to invalidate the usefulness of the acidity determination. Furthermore, in sound corn the acidity of the extract can depend only partly upon zein, and in spoiled corn it can depend only to a slight degree upon it.[a] As a matter of fact it would seem that less nitrogen is extracted when the acidity is high. The question arose whether the lessening of the nitrogen extracted is due to a consumption of zein by the micro-organisms causing the deterioration or whether acidity renders zein less soluble.

To test this, good corn was extracted with neutral alcohol in the usual way and also with alcohol to which sulphuric acid had been added until its acidity corresponded to that of spoiled corn. The result did not come up to expectations, for the differences were insignificant as the following figures show:

Extraction with neutral alcohol and with acidified alcohol.

Sample 16.	Extracted by 85 per cent alcohol.	Extracted by 85 per cent alcohol + 5 c. c. H_2SO_4 N/10.
	Grams.	*Grams.*
Kjeldahl nitrogen	0.0241	0.0221

These negative results, together with the figures obtained for low-protein (No. 28) and high-protein (No. 29) corn, make it probable that it is not the acidity developed but the destruction of alcohol-soluble nitrogenous material which accounts for the low-nitrogen content of the alcoholic extracts of very acid corn.

The conversion of the corn protein into other substances was a matter which gave considerable food for thought. As long as it was not known that zein was an unimportant factor in causing the acidity of the extracts it was deemed possible by the writers that altered zein might be the cause of the acidity. As already pointed out, zein behaves in some respects like an acid. The putrefaction of proteins is accompanied among other processes by their deamidization, i. e., the removal of ammonia, either as such or in the form of amins. The removal of

[a] Prof. L. H. Smith, of the Illinois Agricultural Experiment Station, kindly furnished samples of low-protein and high-protein corn.

ese basic groups might increase the acid properties of the proteins. was possible that zein might in this way become more acid without crificing its solubility in alcohol. However, when it was found that e acidity did not depend to any large degree upon zein the investigaon of this point was postponed to some future time. For the present e fact is noted that the zein from spoiled corn was found to be ifferent from that prepared from sound corn. When freshly precipited it is not so tough, but rather brittle and of a dirty green color, ven when obtained from white corn. It could not be decolorized ith any of the ordinary fat solvents; a study of the nature of the hange is now being made.

These considerations suggest the possibility of corn spoiling so as to ecome alkaline from the formation of ammonia and amins. This rould of course ultimately take place, but probably not until all the tarch in the grain had been used up. When it did occur decomposiion would be so far advanced that use of the corn as food would be uite out of the question. The possibility of ammoniacal decompoition does not therefore vitiate the acidity test.

The nature of the acids formed has also been studied by the writers. This seems to be an intricate question, since it involves more than a simple acetic or lactic acid fermentation. A number of interesting results have been obtained which it is hoped to communicate at a future time. For the present the fact is recorded that a peculiar volatile crystalline acid has been encountered which could not be identified as any of the ordinary fermentation acids. It is possible that it is identical with the acid isolated by Gosio,[a] and it is hoped that its identity may be learned.

ASH DETERMINATION.

The ash determination is done in the usual manner. However, corn is quite difficult to ash without employing temperatures so great that there is danger of loss by volatilization. Experience has taught that the following manipulations are useful. Porcelain is best used, as platinum is badly attacked. The heating is begun with a very small flame, and at least half an hour is allowed for the material to become charred. In this way a porous mass is obtained. Rapid heating causes the meal to char and covers it with a coating of fused salts which effectively keeps the oxygen from gaining access to the carbon. In the course of an hour or two the flame is gradually raised to the full heat of an ordinary Bunsen burner. When after a time the carbon does not seem to be disappearing, the crucible is cooled and water added. This water is then evaporated off on the steam bath. The pieces of carbon float on the surface and climb up the sides of the crucible, so that when the crucible is dry and is again heated they

[a] Op. cit., p. 871 et seq.

burn off readily. Sometimes a second treatment with water is necessary.

In Italy the amount of ash present is regarded as significant. An ash content of over 4 per cent is considered a sure sign of deterioration.[a] Undoubtedly it is. Fermentation increases the ash content because the fungi causing the fermentation consume organic matter in the corn kernel, converting it into carbonic acid and water, which are dissipated into the atmosphere. None of the salts disappear. Consequently, since the organic matter in the fermented kernel is lessened, the relative proportion of salts and similar constituents is increased and the percentage of ash rises correspondingly. An inspection of Table III shows that the ash content of good corn can be considered as being in the neighborhood of 1.5 per cent. Inspection of Tables IV and V shows further that badly spoiled corn (Nos. 11, 25, 26, and 27) does not necessarily have a very high ash content. Only in meal No. 14 is it noticeably high. Evidently conditions are different in Italy or else corn far more badly spoiled than any seen in the course of this investigation is common. There was no sample with more than 2 per cent of ash, yet Tables IV and V show that in a general way ash content and acidity run parallel. The ash determination is troublesome, the acidity determination easy. Therefore in most cases the former may be omitted.

From another point of view the ash determination is significant. It gives an indication as to how completely a meal has been degerminated and the starchy layer of the endosperm removed. Nearly all the ash of the kernel is located in the germ. Hence, the poorer the meal in ash the more complete the removal of the germ and the adjacent starchy layer. How desirable it is to degerminate corn has already been shown. This is again expressed in the ash and acidity determinations of Table V. Thus, the meals most completely degerminated, those with the lowest ash content, show also the lowest acidity. Nos. 16 and 18 were yellow meals milled for the northern market and consisted almost exclusively of the horny layer of the endosperm. The very fact that American meals vary so much in the degree of degermination renders ash determinations an unsatisfactory method for the examination of meal. Thus, meal made from thoroughly degerminated corn would have a low ash content. Subsequently, owing to moisture or faulty storing, it might become very bad indeed without showing an ash content as high as that of meal from whole corn.

FAT DETERMINATION.

Although the ash determination gives an index of the degree of degermination of a meal, this can be estimated more accurately by a

[a] Antonini, G., op. cit., p. 74.

t determination. The germ contains only 10 per cent of ash, but has often over 30 per cent of oil. Consequently, the fat determi-tion is the more delicate index of the two. Whole corn contains the average about 4.3 per cent of fat. High-grade, rather coarse eal, consisting only of the horny layer, may contain as little as 0.8 r cent of fat. Meals on the average will vary between these limits cording to the degree of degermination. In one other direction e fat determination is useful. It makes it possible sometimes to termine whether a meal has been adulterated with the germ. No ich case has been met with in the present research, but it seems to ave been attempted in Europe. Millers have there adulterated ieir low-grade meals with the germ obtained as a by-product in the anufacture of their high-grade meals. Such adulterated meal will f course show a fat content high above that of whole corn.

The fat determinations are carried out in the usual way with a oxhlet extractor.

THE PHENOL REACTION OR TEST OF GOSIO.

In Italy much stress is laid upon the phenol reaction. Schindler[a] liscards it as uncertain; it could be obtained only once, in sample Io. 25, the worst one dealt with. This fact strengthens the suspicion hat corn as bad as that which seems to be common in Italy is rare n this country.

The phenol test depends upon the formation by molds of sub-stances giving color reactions with ferric chlorid. The Penicillium nolds, or at least some of them, are said to produce this substance or substances. Gosio[b] has endeavored to isolate the substance. He obtained a small amount of a crystalline substance giving a color with ferric chlorid, possibly parahydrocumaric acid. It was not toxic. Gosio,[b] Gosio and Ferrati,[c] and Antonini and Ferrati[d] all believe that the toxic substance and the substance giving the color with ferric chlorid are identical. They believe that the toxicity and the reaction of Gosio run parallel. These views are not accepted by all Italians and have been particularly vigorously attacked by Ceni.[e] Most Italian investigators believe this reaction to be caused by phenols

[a] In a personal communication.

[b] Op. cit., p. 869 et seq.

[c] Gosio, B., and Ferrati, E. Sull' Azione Fisiologica dei Veleni del Mais Invaso da Alcuni Ifomiceti. Rivista d'Igiene e Sanità Pubblica, vol. 7, 1896, p. 961.

[d] Antonini, G., and Ferrati, E. Sulla Tossicità del Mais Invaso da "Penicillium glaucum." Archivio di Psichiatria, Scienze Penali ed Antropologia Criminale, vol. 24, p. 581.

[e] Ceni, C. Sulla Reazione Fenolica in Rapporto coi Tossici Pellagrogeni. Rivista Pellagrologica Italiana, vol. 6, 1906, p. 60.

or phenol-acids. This belief is based not upon the isolation and chemical identification of these substances, but upon the ferric-chlorid reaction and the fact that extracts giving this reaction kill mice with symptoms resembling carbolic-acid poisoning. When it is considered how many substances give color reactions with ferric chlorid and, further, how difficult it is to form any opinion of the identity of a poison from the symptoms it produces in animals, it must be concluded that it is premature to pass judgment on the chemical nature of these substances.

In its original form the reaction of Gosio is performed in either of the following ways:

(*a*) From 50 to 100 grams of meal are warmed for several hours in twice their volume of 80 per cent alcohol. The alcohol is then filtered off into a porcelain dish and evaporated to dryness. The residue is then taken up with warm water, filtered, and the filtrate treated with a dilute solution of ferric chlorid. A coloration varying from dark green to bluish violet results.

(*b*) The meal is suspended in water acidified with a few drops of phosphoric acid. The acid suspension is exhausted with ether, the ethereal extract evaporated to dryness, and the residue tested as above.[a] Antonini[b] advises that if the first-mentioned procedure is followed the extraction be continued for several days, shaking from time to time and exposing to the sunlight. In order to avoid resins and fats which may obscure the reaction, the residue may be extracted with boiling water, the extract filtered, and the filtrate tested. If the second procedure is followed, he advises using three times as much 1 per cent phosphoric-acid solution as corn (by volume) for the extraction, and he prolongs it for several days, shaking thoroughly, exposing to sunlight, and warming slightly. The writers attained the best success with this modification. When the extraction has gone on long enough, the suspension is cooled, and then treated with two to three volumes of ether. This is allowed to separate and the clear ether, which alone should be used, is decanted. It is shaken out repeatedly with distilled water to remove impurities. Finally, the clear ether is decanted from the water, distilled off, and the residue tested.

According to Antonini, Camurri has modified the test of Gosio by distilling the meal with water or steam and performing the reaction upon the distillate. The reaction is said to be even more distinct if it be performed upon the ethereal extract of the distillate.

THE REACTION OF ORI.[c]

The reaction of Ori depends upon the fact that molds contain or produce a substance or series of substances which decompose per-

[a] Gosio, B., op. cit., p. 883. [b] Op. cit., pp. 74–75. [c] Ori, A., op. cit.

oxid of hydrogen catalytically. The substance producing this decomposition is believed to be an enzyme and has been called catalase. It is probably of universal occurrence in living things and therefore also occurs in the corn kernel. However, it seems to be more abundant in molds than in corn. Consequently, moldy corn or moldy meal will decompose peroxid of hydrogen more powerfully than good corn or good meal. The reaction is carried out as follows:

Five grams of meal are extracted for half an hour with 15 c. c. of a 50 per cent aqueous solution of glycerin. The extract is then filtered through paper; 1 c. c. is put in a watch glass and 4 to 5 drops of a 3-per cent peroxid of hydrogen solution added. Good degerminated meal gives no bubbles at first, while bad meal produces a strong effervescence almost at once.

The writers conclude that in general this reaction gives a good indication of the condition of the meal if the meal be thoroughly degerminated. As Ori himself points out, the reaction is more reliable than that of Gosio, while, as his figures show, it runs parallel with the acidity. Judged by his figures, it does not seem to be more delicate. Now, good corn kernels, as already stated, contain a certain amount of catalase, and therefore meal made from whole corn decomposes peroxid of hydrogen to a certain extent. Usually, however, this is not as extensive as when the corn is moldy. The writers found by taking corn kernels, splitting them, paring the germ carefully away, and making extracts separately of the endosperm and the germ that the catalase is located almost exclusively in the germ.[a] The extract of the germ gives practically as powerful a reaction as spoiled meal. Here, then, are possibilities of confusion. Thoroughly degerminated meal ought not to decompose peroxid of hydrogen. Meal from good whole corn will decompose peroxid of hydrogen to a certain extent. Hence, it is conceivable that meal from very thoroughly degerminated corn may become somewhat moldy and yet give Ori's reaction no more intensely than meal from good whole corn. Therefore, in order to form a correct estimate of the value of the reaction in any given case it ought to be known whether the product was obtained from degerminated material. Viewed from this aspect the reaction of Ori has its value. On the other hand, there is another possibility. It seems conceivable that meal might be made from corn spoiled in such a way that the molds were situated mainly in the germ. If in the process of milling the corn were thoroughly degerminated and carefully bolted, the greater part of the molds might be removed.

[a] Since making these experiments it was discovered that similar observations upon wheat have been made very recently by P. Liechti. See Die Prüfung von Mehlen auf Grund ihres Gehaltes an Katalase, Vorläufige Mitteilung, Chemiker Zeitung, vol. 33, p. 1057.

In such a case the corn might show a fairly high acidity and nevertheless a weak reaction of Ori. Meal with high acidity and negative action upon peroxid of hydrogen was actually encountered by Ori, and he points out that this phenomenon might in some way be connected with degermination.[a] There is still another factor to be taken into consideration. Catalase is an enzyme. It is therefore weakened or destroyed by temperatures of 60° C. and higher. Artificially dried corn might, therefore, when carelessly dried, lose its power to decompose peroxid of hydrogen.

It is quite possible that with these limitations this reaction might be developed into a useful rapid method if it were made quantitative. This ought to be easy, either by measuring the volume of oxygen evolved in a unit of time or by titrating the excess of peroxid of hydrogen remaining after a given time.

Ori has also suggested another test based upon the fact that corn does not contain appreciable amounts of invertase, while most molds do. It is applied by putting 30 grams of meal into a flask with 90 cubic centimeters of 50 per cent aqueous solution of glycerin. After standing for twenty-four hours the extract is filtered off and twice its volume of 90 per cent alcohol added to it. The precipitate formed by the alcohol is collected upon a filter and dissolved in 45 c. c. of distilled water. Of this solution 2 c. c. are added to 50 c. c. of a 10 per cent cane-sugar solution and the mixture incubated for twenty-four hours at 50° C. It is then tested for reduction and the sugar titrated. Good meal should produce no reduction or only a minimal one. This test has not been used in this investigation.

THE DETERMINATION OF TOXICITY.

Much stress is laid in Italy upon the determination of toxicity. Schindler does not even mention it. It is performed as follows: A weighed quantity of meal is extracted at about body temperature with 90 per cent alcohol for twenty-four hours. It is then filtered and the alcoholic filtrate evaporated until the alcohol is removed. The residue is taken up in water at a temperature of 40° C., made up with warm water to a definite volume so that 0.5 c. c. corresponds to about 0.5 grams of the meal, and an amount equivalent to 0.5 grams of meal injected subcutaneously into a mouse. Larger quantities of liquid are often injected, but this seems open to objection in so small an animal. The mouse is chosen because it is supposed to be the most sensitive to the poison.[b] The symptoms are described as consisting of clonic spasms and localized contractures of the muscles, embarrassed respiration, gradual paralysis, collapse, death. Sometimes

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[a] Ori, A., op. cit., p. 187. [b] Gosio, B., and Ferrati, E., op. cit., p. 964.

pisthotonos ensues. On autopsy little is said to be noticeable except flammation at the site of injection and hyperæmia of the cord.

A sample of corn which was toxic when injected in the dosage given bove was never encountered in the present investigation. However, the procedure was varied from that of the Italians because of the llowing considerations: The extracts may be very acid. It is well nown that herbivorous animals are very sensitive to acids which ney are incapable of destroying in their metabolism. The symptoms f such an acid intoxication (acidosis) are, however, different from hose described above. The behavior of mice toward acid intoxication is not known so far as a hasty search of the literature has shown. t is therefore conceivable that some of the toxic effects of the injection of corn extracts may merely have been acid effects. For these easons the solutions injected were usually neutralized. Perhaps that s why toxic effects were not obtained. In this connection it is intersting to note that Gosio and Ferrati[a] distinctly state that alkali eutralizes the poison, and in another place that culture fluid of Penicillium cultures becomes less toxic as the culture grows older and ts acidity diminishes.

TESTS FOR MICRO-ORGANISMS AND FOR A TENDENCY TO BECOME MOLDY.

The test for micro-organisms and the tendency to become moldy nvolves the quantitative determination of the number of organisms n the suspicious sample compared with a sound sample. The methods hitherto proposed for this purpose do not seem to be adequate. To devise improved ones and to determine the nature of the organisms present is beyond the limits of the present problem. This has been undertaken by Dr. Erwin F. Smith, of the Bureau of Plant Industry, and he will no doubt report in due time.

A number of other tests have been proposed by various authors, such as the application of Millon's test and the bromin water test, to corn extracts. They are based on the assumption that the toxic substances of spoiled corn are phenols. Neither seems to offer any special advantage.

These, then, are the chief methods hitherto used for determining the fitness of corn for food. Although the writers lay the most stress upon the determination of acidity, each of the other tests has its uses. Under ordinary circumstances the examination will probably have to be limited to the acidity determination, while the expert food chemist and bacteriologist will control his results by using a number of other methods and thus reach an estimate more nearly correct than any single method can give.

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[a] Op. cit., p. 978.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 200.

B. T. GALLOWAY, *Chief of Bureau.*

BREEDING NEW TYPES OF EGYPTIAN COTTON.

BY

THOMAS H. KEARNEY,

PHYSIOLOGIST IN CHARGE OF ALKALI AND DROUGHT RESISTANT PLANT BREEDING INVESTIGATIONS.

ISSUED DECEMBER 23, 1910.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1910.

BUREAU OF PLANT INDUSTRY.

Chief of Bureau, Beverly T. Galloway.
Assistant Chief of Bureau, G. Harold Powell.
Editor, J. E. Rockwell.
Chief Clerk, James E. Jones.

ALKALI AND DROUGHT RESISTANT PLANT BREEDING INVESTIGATIONS.

SCIENTIFIC STAFF.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., August 18, 1910.

SIR: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 200 of the series of this Bureau the accompanying manuscript, entitled "Breeding New Types of Egyptian Cotton," by Mr. Thomas H. Kearney, Physiologist in Charge of Alkali and Drought Resistant Plant Breeding Investigations.

As a result of experiments that have been carried on for the past seven years in acclimatizing and breeding Egyptian cotton in the southwestern United States, several distinct types have originated from the stock of imported seed of the Mit Afifi variety with which the work was begun. Two of these are as distinct in the characters of the plants, bolls, and fiber as some of the newer varieties which have originated in Egypt from the Mit Afifi. A third promising type is an improved acclimatized strain of Mit Afifi rather than a new variety.

The principal object of the present publication is to describe the leading characteristics of these promising varieties and strains and the methods followed in the plant-breeding work. A brief account is also given of the general progress of the acclimatization experiments with Egyptian cotton during the year 1909.

The United States continues to import large quantities of staple cotton. In 1909 the imports from Egypt amounted to 72,617,893 pounds, valued at $12,101,000. Spinners who have examined samples of the acclimatized Egyptian fiber grown last year in the Southwest pronounce it to be in every way as well adapted to their requirements as imported cotton of corresponding grades.

The possibility of growing Egyptian cotton of good quality on the irrigated lands of southern Arizona and southeastern California has been demonstrated. Production on a large scale awaits the solution of certain cultural and commercial problems which are now receiving attention.

Respectfully,

G. H. POWELL,
Acting Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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BREEDING NEW TYPES OF EGYPTIAN COTTON.[a]

INTRODUCTION.

The work of the Bureau of Plant Industry with Egyptian cotton in the Southwestern States and Territories involves three closely related but somewhat distinct lines of investigation, as follows:

(1) Plant-breeding investigations, the object of which is to secure improved, high-yielding varieties and strains by the selection of superior individuals producing fiber which represents the best commercial types of Egyptian cotton. The present publication deals mainly with this phase of the work.

(2) Acclimatization investigations, the object of which is to study the diversity exhibited by imported and by more or less acclimatized stocks when planted under different environmental conditions, so as to ascertain what environments and what cultural conditions are most favorable to uniformity, fruitfulness, and the production of good lint in each stock.[b]

(3) The study of irrigation and other cultural methods for growing the crop and of industrial methods for preparing and marketing the product. These studies are directed by the officers of the Bureau of Plant Industry who are in charge of the cooperative

[a] The general results of the experiments with Egyptian cotton in the southwestern United States up to the end of the year 1908 were described in Bulletin 128 of the Bureau of Plant Industry, entitled "Egyptian Cotton in the Southwestern United States," and in Circular 29 of the same Bureau, entitled "Experiments with Egyptian Cotton in 1908," both publications being by Thomas H. Kearney and William A. Peterson.

[b] Some of the results of the investigations in this field by Mr. O. F. Cook and his assistants are described in the following publications of the Bureau of Plant Industry: Bulletin 147, entitled "Suppressed and Intensified Characters in Cotton Hybrids," by O. F. Cook, 1909; Bulletin 156, "A Study of Diversity in Egyptian Cotton," by O. F. Cook, Argyle McLachlan, and Rowland M. Meade, 1909; Circular 42, "Origin of the Hindi Cotton," by O. F. Cook, 1909; Circular 53, "Mutative Reversions in Cotton," by O. F. Cook, 1910.

work with the Reclamation Service and with the Office of Indian Affairs, respectively. Mr. W. A. Peterson, superintendent of the cooperative experiment farm of the reclamation project at Yuma, Ariz., and Mr. E. W. Hudson, superintendent of the cooperative experiment farm on the Pima Indian Reservation at Sacaton, Ariz., are in immediate charge of the cultural experiments. Most of the experimental work with Egyptian cotton in the Southwest has thus far been carried on at these two stations.

In 1909 the plant-breeding plats were located in the Yuma Valley[a] and at Sacaton, Ariz. In the Yuma Valley two fields were planted with bulk seed of the two most promising of the new types described later, four fields were each planted with imported seed of one of the Egyptian varieties, and various smaller experimental plantings were made. At Sacaton, in addition to the plant-breeding plat and the plats grown from imported seed of Egyptian varieties, a field of 10 acres was grown from mixed seed of the "bulk selections" made at Sacaton in 1908. In the Imperial Valley, California, small field plantings of four different types of the acclimatized stock were made, each in a different locality. Another of the acclimatized types was tested at Glendale, near Los Angeles, Cal., alongside a planting of newly imported seed of the Mit Afifi variety.

The results of the season's work were on the whole very encouraging. For the first time in the course of these experiments, fields of several acres each were planted to high-bred varieties and strains, each derived from a single individual plant selected in the breeding nursery only two years previously. A gratifying degree of uniformity in the plants and fiber was exhibited. The best three of these new types are described in detail in the present publication. Two of them, the "Yuma" and the "Somerton" varieties, are so distinct from the Mit Afifi variety, with which the breeding work was begun, as to warrant the assumption that they constitute mutations. The third (strain No. 361) is a typical Mit Afifi, but superior in yield, earliness, and quality of the fiber to plants grown from imported seed of that variety. This strain is apparently a product of acclimatization and selection without the aid of mutation.

The great amount of diversity that manifested itself in the experimental fields in 1908 was largely eliminated, partly as a result of planting these selected stocks and partly through the application of methods of "roguing" at an early stage in the development of the

[a] The experimental plantings in the Yuma Valley in 1909 were located near the village of Somerton, about 14 miles south of the town of Yuma. In 1910 most of the experimental work near Yuma is located on the new cooperative experiment farm situated on the California side of the Colorado River, about 7 miles above the town of Yuma.

plants which Mr. Cook has worked out as a result of his studies of diversity. Samples of the fiber produced at Somerton and Sacaton in 1909 were submitted to a number of buyers and spinners, who have given uniformly favorable reports on its quality. Comparisons with cotton of the corresponding grades imported from Egypt have invariably been favorable to the Arizona product.

NEW TYPES DEVELOPED.

The varieties and strains[a] of Egyptian cotton described in this paper were derived from a stock of seed of the Mit Afifi variety imported from Egypt by the Office of Seed and Plant Introduction and Distribution and tested at several localities in the Southwest in 1902.[b] They are all descended from individual-plant selections made in the field at Carlsbad, N. Mex., that was planted with this seed. In 1906 the surviving progenies of these selections were transferred to Yuma, Ariz., and since then the breeding work has been continued in that locality. In 1909 a plant-breeding nursery was started at Sacaton, Ariz., with seed of a number of individual selections from the progeny rows at Yuma of the previous year, in addition to seed of a number of individual selections made in 1908 in the 10-acre field at Sacaton.[c]

[a] In this bulletin the term "variety" is applied to such of the new forms as can easily be distinguished from the original stock by their botanical characters. The two new varieties described are believed to have originated as mutations. Where the differences are simply of degree—greater fruitfulness, earlier ripening, longer and stronger fiber, etc.—and no evidence of mutation is shown, the term "strain" is employed.

[b] For an account of the earlier experiments, see Bulletin 128, Bureau of Plant Industry, United States Department of Agriculture, 1908, pp. 34–45.

[c] The field planting of 1908 at Sacaton was made with mixed seed from the 1907 breeding rows at Yuma. As would be expected, considerable diversity was noted among the plants in this field. A large number of individuals which were superior to the average in fertility and in fiber qualities and which appeared to be purely Egyptian in all their characters were marked and picked separately. The mixed seed from these plants was used for planting the "general field" at Sacaton in 1909, in order to ascertain the general fertility and state of acclimatization of the stock after the removal of all hybrids and other conspicuously inferior individuals and to afford a further opportunity for the selection of desirable types of plants that might appear under the Sacaton conditions. The result was a marked improvement in average fruitfulness and in the quality of the fiber as compared with the 1908 field. The same method of "bulk selection" was repeated in 1909. It will be interesting to compare the performance of this second generation of bulk selections with that of carefully selected varieties and strains derived from single individuals, which will also be tested on a field scale at Sacaton in 1910.

METHODS OF SELECTION.

The breeding methods employed have been very simple. At the outset all the plants in the test field were examined, and those individuals which were most fruitful, ripened earliest, and had the largest bolls and the best fiber were given numbered tags and were picked separately. The seed cotton from these plants was then carefully compared in the laboratory and the final selection of the most promising individuals was made.

The following year the seed from each of these selections was planted in a progeny row, and each row was marked with the number of the corresponding selection. When the bolls began to open in the fall the rows were carefully worked over, and the best individuals were selected. This process has been continued year after year.

As the work developed, the methods were improved. Latterly more importance has been attached to the "projected efficiency" of the individual selections as shown by the greater or lesser degree of uniformity in the good qualities of their progeny. It is now the practice to begin the work of selection each year by a general survey and comparison of the progeny rows as units. As a result, many of the rows can be rejected at once, either because the plants show too much diversity or because their average fruitfulness, length of lint, and other qualities are inferior. Further consideration is given to only those rows which show a high degree of uniformity and in which at least a majority of the individuals are desirable in all essential qualities.[a] The best individuals in the superior rows are then selected by careful comparison in the field, the branching habit and productiveness of the plants and the size of the bolls being noted and the lint from a number of bolls on different parts of the plant being combed out and examined in respect to length, strength, and general quality.

Evidence has accumulated to the effect that the type of branching of the plant is one of the most important characters to be considered in making selections. Plants which bear a large proportion of the bolls on the fertile branches of the main stem, with a corresponding reduction in the size of the "limbs,"[b] are to be preferred because

[a] An exception should be made to this rule in the case of strikingly superior individuals which are so distinct as to warrant the belief that they are mutations. Such individuals should be retained even if the rows in which they occur are otherwise inferior, in view of the generally admitted tendency of mutations to be prepotent.

[b] The distinction between the fertile branches and the "limbs," or large vegetative branches (which in Egyptian cotton are produced only at a few of the lowest nodes of the main stem), is well expressed by Mr. O. F. Cook in Bulletin 156 of the Bureau of Plant Industry, p. 29: "The branches of the cotton plant are of two definitely different forms. Fertile branches are horizontal or drooping

they are much easier to pick and because the ripe bolls are held up better and escape contact with dust and mud. The ability to develop fruiting branches at low nodes of the axis—in other words, to set a "bottom crop"—is a desirable character, being an important factor in great fruitfulness. The size of the bolls must be considered, not only because large bolls make picking easier, but because this character is intimately associated with length of fiber.[a] It was discovered last year that an examination of the breeding rows several weeks before the bolls begin to ripen is exceedingly helpful, since it is much easier at that period to compare the different rows in respect to type of plant and amount of diversity. The percentage of contamination that has resulted from previous crossing with other types is especially easy to determine at this early stage.

The seed cotton from the preliminary selections made in the field is picked separately, and the fiber is carefully examined and compared on the seed in the laboratory. The seed cotton from each plant is then ginned, and the color of the resulting fiber is determined by matching with imported samples of the different Egyptian varieties.[b] The average amount of fuzz on the seeds is also recorded after ginning. By a careful comparison of the field notes on productiveness, earliness, vegetative characters of the plants, and size of the bolls with the results of the examination of the fiber in the laboratory, the final choice is made of the selections to be retained for planting in progeny rows the following year, and the rest are discarded. The more promising types are tested on a field scale by planting in differ-

Each joint bears a fruit bud, and the internodes are twisted to bring the buds to the upper side. Sterile branches, or 'limbs,' are upright or ascending, with long straight joints and no fruit buds. The sterile limbs are to be thought of as subdivisions of the main stalk and have the same function. Like the main stalk they can produce other branches which are fertile, but are themselves unable to set any flowers or fruits."

[a] Mr. O. F. Cook has called attention in Bulletin 159 of the Bureau of Plant Industry, p. 45, to the existence of this correlation between the length of the boll and the length of the fiber. The writer has observed that in Egyptian cotton, although extremely long, narrow bolls sometimes contain inferior fiber, very short, rounded bolls are never correlated with long lint.

[b] Mit Afifi has the most deeply colored fiber. A comparison of the imported sample of this variety, which has been used as a standard, with the hand-painted specimens of color tints given in Ridgway's "Nomenclature of Colors" (Boston, 1886) shows the color of this sample to be very nearly intermediate between "cream-buff" and "pinkish-buff"; Nubari is somewhat lighter colored, corresponding very nearly with the "cream color" of Ridgway; Jannovitch fiber is much lighter colored than Nubari and may be described as of a very pale tint of cream color; Abbasi fiber is white, tinged with cream. To conform with commercial usage, however, the terms "brown" (Mit Afifi), "light brown" (Nubari), "cream colored" (Jannovitch), and "white" (Abbasi) will be used in this paper.

ent localities the mixed seed from the unselected plants in the progeny rows. The degree to which the type maintains its uniformity and desirable qualities of plant and fiber when grown in large fields, especially if at different localities affording a considerable diversity of climatic and soil conditions, is, of course, the final measure of its agricultural value.

The types represented by progeny rows in the breeding nurseries at Yuma and Sacaton in 1909 were designated by the following numbers: 300, 301, 310, 320, 330, 340, 350, 360, 361, 362, 363, 370, 380, 382, 383, and 390. Each of these numbers is that of an individual selection made at Yuma in 1907 and of the corresponding progeny row grown at Yuma in 1908. All types the numbers of which belong to the same decade (as 300 and 301, 360 to 363, etc.) are closely related, having been derived from the same individual plant selected at Yuma in 1906. All types numbered from 300 to 340, inclusive, came from one individual selected in the field at Carlsbad, N. Mex., in 1902, and all those numbered from 350 to 390, inclusive, are derived from several individual selections made in the breeding nursery at the same place in 1905.[a]

The progenies of numerous individual selections in each of the above types were grown on the "plant-to-a-row" system in the breeding nurseries at Yuma and at Sacaton in 1909. Strain No. 361 and the Yuma variety (No. 382) were tested on a field scale near Yuma, seed from the unselected plants in the respective progeny rows of 1908 having been used for these plantings. Selections from the progeny rows of the following seven types have been planted in the breeding nurseries of the present year (1910) at Yuma and Sacaton: Nos. 301, 310, 360, 362, 370 (the Somerton variety), 382 (the Yuma variety), and 390.

Heretofore the various progeny rows of all the types represented have been grown side by side in the breeding nurseries, with no attempt to isolate one from another. Even under these conditions most of the rows in 1909 showed a definite unity of type. This indicates a strong tendency to prepotency in the characters of several of these types, for in Arizona the Egyptian cotton generally crosses very freely even with other species when grown near by, and a high percentage of hybrids results.[b] Hereafter, in order to prevent, if possible, any

[a] Owing to an accident to the stakes at the heads of most of the rows in the breeding nursery of 1905, the detailed records of the earlier ancestry of strains 350 to 390 were lost, but they are all descended from the same stock of imported Mit Afifi Egyptian seed that was grown at Carlsbad in 1902.

[b] Owing to the fact that plats of Upland varieties were grown in the neighborhood of the breeding rows of Egyptian cotton at Yuma in 1907, many of the progeny rows in 1908 contained a high percentage of hybrids. In one row there were as many as 25 per cent of first-generation Egyptian-Upland hybrids.

contamination due to intercrossing of the different stocks, the progeny rows of each of the most promising types will be isolated, as far as practicable, from all cotton of different ancestry.

The three most promising types that have so far been developed in the course of this breeding work are described in detail in the following pages. The remaining types either appear less promising or have not yet been sufficiently tested.

THE YUMA VARIETY.

Type No. 382, here designated the "Yuma" variety, is upon the whole the most promising that has so far been developed in this breeding work, and is the one which has been most thoroughly tested on a field scale. In 1909 a field of 4¼ acres near Yuma, Ariz., was planted to this seed, and a high degree of uniformity was noted in the characters of the plants, which were very productive and had large bolls with lint of good quality. Seed of the Yuma variety was planted in 1910 at all localities where experiments with Egyptian types of cotton were undertaken, in order to test its power of retaining its desirable qualities under a variety of conditions of climate and soil.

HISTORY OF THE VARIETY PREVIOUS TO 1909.

The progenitor of the "Yuma" variety was a plant selected in the breeding nursery at Carlsbad, N. Mex., in 1905. It was derived from the stock of Mit Afifi Egyptian seed planted at Carlsbad in 1902, from which all the other types described in this paper are likewise descended. In the progeny row grown at Yuma, Ariz., in 1906 from the Carlsbad selection an individual was selected which was characterized by high productiveness, very large bolls, nearly smooth seeds, a high percentage of lint (32 per cent), and fiber that was very satisfactory in length, strength, and fineness. The progeny plants of this selection in 1907 were of excellent average quality. One of the selections, No. 382, from this progeny row was the immediate progenitor of this variety. It was a very productive plant, with large, long-pointed bolls, and its fiber was silky and lustrous, very strong, and more than 1½ inches in length.[a] The lint percentage (27) was considerably lower than that of its progenitor in 1906.

The amount of crossing which takes place under these conditions in Arizona seems far in excess of what has been observed by most cotton breeders in the eastern United States. It can doubtless be attributed to the unusual abundance of wild bees and other flower-visiting insects in the cotton fields during the summer and early fall.

[a] Measurements of length of fiber are copied from the score cards of the year the sample was grown. It is probable that the length was somewhat too favorably estimated previous to 1908, the earlier practice having been to give the

The progeny row in 1908 from selection No. 382 was remarkably uniform in the characters of the plants, bolls, and fiber.[a] The plants were characterized by great productiveness and by a habit of growth (Pl. I, fig. 2) that distinguished this row from all the other progeny rows in the nursery. They had a tall, stout main stem, which generally greatly surpassed the limbs and bore an exceptionally large proportion of the bolls. The bracts of the involucre were very large and the bolls were long and pointed. The seeds were generally nearly smooth. The average length of fiber equaled or exceeded that of any other of the 1908 progeny rows, and the length throughout the row was fairly uniform. The seed cotton from all the unselected plants in this row was picked and ginned together. As measured by Mr. John A. Walker,[b] the resulting lint ranged from 1¼ to 1⅜ inches in the first picking, 1⅜ to $1\frac{7}{16}$ inches in the second, and $1\frac{7}{16}$ to 1½ inches in the third picking. In respect to fineness, Mr. Walker classed the lint from the first two pickings as "fine" and that from the third picking as "strictly fine and silky." He found the strength to be "fair" in the first picking and "extra" in the second and third, but in all three pickings the strength was slightly uneven. The color of the lint from all the pickings was light brown.

Twenty individual selections were made in this row, and the seed cotton from each was carefully compared. Although the fiber was generally of high quality, there was much diversity among the different plants and even on the same plant, especially as between the first and the third pickings. In 13 of these plants the fiber had the same color as imported samples of the Jannovitch variety (see footnote *b*, p. 11), in 4 plants the color was intermediate between Jannovitch and Nubari, in 1 plant the fiber was nearly as brown as Nubari, and in another nearly as white as Abbasi. The maximum length of fiber in the 20 selections ranged from $1\frac{5}{16}$ to $1\frac{11}{16}$ inches, in 16 plants the length did not fall short of 1⅜ inches, in 7 plants none of the fiber was shorter than $1\frac{7}{16}$ inches, and in 2 plants the minimum

fibers a decided pull in straightening them out before measuring them. During the last two years the fibers have been merely smoothed out, without applying tension. It is therefore probable that the deterioration of the progeny of many of the selections which is indicated by length of the fiber shown on the score cards is apparent rather than real. It is believed that the method now followed gives a better idea of the length as usually estimated commercially on samples of ginned cotton; error, if any occurs, is in the direction of too great conservatism.

[a] This row contained only 4 per cent of first-generation Egyptian-Upland hybrids, as compared with 6 to 25 per cent in eleven other rows in the breeding nursery. The small percentage of hybrids in row 382 indicates a high degree of prepotency in this type.

[b] An expert grader of Egyptian cotton, employed by the Bureau of Plant Industry to classify the lint from the different experimental plantings in Arizona in 1908.

length was $1\frac{1}{2}$ inches. The variation in length on the same plant was generally considerable, especially as between the first and the third pickings. The fiber was uniformly silky and very fine, especially in the later pickings. In nearly all plants the strength was satisfactory, and in 7 out of the 20 it was highly so. The percentage of lint varied considerably, having been only fairly good on 8 out of the 20 plants, while on the other 12 it was more satisfactory. In 10 out of the 20 selections the seeds varied from nearly smooth to partly covered with fuzz, in 5 they were nearly smooth, and in the other 5 they varied from nearly smooth to completely fuzzy. The third picking almost always showed a higher percentage of nearly smooth seeds than did the first.

BREEDING EXPERIMENTS IN 1909.

The seed from 14 of these selections was planted in 1909 in progeny rows, 8 at Yuma and 6 at Sacaton. When inspected by Mr. Argyle McLachlan on July 6, there was considerable diversity in 3 of the 8 rows at Yuma, although the foliage type (large, thick, dull-colored, generally three-lobed leaves) was fairly uniform in all. In one row no evident hybrids were found, while in the other rows 2 to 6 per cent of the plants were hybrids and were rogued out. In September the tendency to develop a stout main stem greatly overtopping the limbs was found to be much less pronounced than in progeny row No. 382 of 1908. The plants were generally productive and early ripening, with long spreading or drooping fruiting branches well furnished with bolls. The bracts were large, the bolls large and taper pointed, and the seeds generally partly covered with fuzz.[a] The color of the fiber was generally about that of imported Jannovitch, but was frequently a deeper shade of brown. An unfavorable character was the readiness with which the ripe seed cotton dropped from the open bolls, a peculiarity which necessitates frequent picking. In 4 of the 8 rows at Yuma no selections were made, the fiber having been uniformly short. In fact, none of the rows averaged nearly as good in length of fiber as did the progeny row of 1908 in which their progenitors were selected.

In the 6 rows at Sacaton the plants were very similar in habit, foliage, shape of bolls, productiveness, early ripening, and fiber characters to those at Yuma. One row contained no recognizable hybrids, but from each of the other rows 1 to 5 hybrids or otherwise aberrant individuals were rogued out on August 3. Two of these rows were later discarded, the fiber being uniformly too short to warrant making selections.

[a] There is a general tendency to an increased development of fuzz on the seeds in Egyptian cotton grown for several generations in the Southwest.

Individual selections of the Yuma variety were made in 1909 in 4 of the progeny rows at Yuma and in 4 of the rows at Sacaton, the total number of selections being 16 at Yuma and 23 at Sacaton. In addition to these, 32 individual selections were made in the large field planted to this variety at Yuma, which is described in the following paragraphs. The seed of these selected plants is being grown in progeny rows at Yuma and Sacaton in 1910.

FIELD TEST IN 1909.

Seed from the unselected plants in progeny row No. 382, grown at Yuma in 1908, was picked together and was used in 1909 for planting a field of 4¼ acres in the Yuma Valley. The soil was a rather light loam, and although probably as uniform as could be found in any area of equal size in that locality, there was sufficient difference in soil texture in different parts of the field to cause certain spots to dry out more rapidly after irrigation. The plants in these spots were smaller, the leaves smaller and lighter colored, the flowers opened earlier, and the bolls were generally smaller and opened earlier than elsewhere in the field. The lint was also generally shorter, coarser, and weaker on the plants growing in these spots.

From June 17 to June 22 this field was carefully inspected by Mr. Argyle McLachlan, who rogued out about 2 per cent of the total number of plants as being hybrids or otherwise conspicuously aberrant. On July 24 the field was again carefully examined by Mr. McLachlan and the writer; the plants then appeared remarkably uniform in branching habit, foliage, and other characters. Upon closer examination about one-half of 1 per cent of the plants were found to give indications of hybrid origin or were otherwise aberrant, and these were removed. As the result of these two roguings, therefore, not more than 2½ per cent of the entire stand of plants were found to be appreciably different from the type of the variety. This indicates a very satisfactory degree of uniformity and also a high degree of prepotency, since the progeny row of 1908, which furnished the seed for planting this field, was situated among rows of very different types, in some of which there was a high percentage of hybrids with Upland varieties. (See footnote *b*, p. 12.) Such diversity as was exhibited later in the season by the plants that remained after the second roguing seemed to be well within the limits of individual fluctuation in a "pure" type.

The total yield from this field of 4¼ acres was 7,390 pounds of seed cotton, or 1,740 pounds per acre. On the basis of an average lint percentage of 27.5 [a] this is equivalent to a yield of slightly above 475 pounds of fiber per acre.

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[a] A 25-pound sample of seed cotton from the first picking yielded 29 per cent of lint, an equal weight from the second picking 30.4 per cent, and an 85-pound

The relatively low percentage of lint given by the acclimatized Egyptian cotton as compared with the percentages reported in Egypt and those obtained during the earlier years of the acclimatization work in the Southwest is largely explained by an observation made by Mr. McLachlan, who finds that the delinted seeds are considerably larger and heavier in the acclimatized types as now developed. Mr. McLachlan found that imported Mit Afifi seed cotton gave a lint percentage of 33 to 35 and that the delinted seeds weighed only 10 grams per 100. The acclimatized Yuma variety, which gave only 27.5 per cent of lint, had seeds weighing 13 grams per 100. If the seeds had weighed no more than imported Mit Afifi seeds the lint percentage of the Yuma variety would have been 33 (a satisfactory percentage for Egyptian cotton) instead of 27.5. Evidently, therefore, no actual diminution in the quantity of lint on the individual seeds has taken place during the process of acclimatization.

CHARACTERS OF THE PLANTS AND FIBER.

The distinctive features of most of the plants in this field were the same as those of the select progeny rows of the Yuma variety as previously described. The plants (Pl. I, fig. 2) were large and showed a strong tendency to develop a stout main stem surpassing the limbs in height and to produce and retain their fruiting branches well toward the base of the main stem and larger limbs.[a] The fruiting branches were long and spreading or drooping and bore numerous bolls. The

sample from the third picking 27.2 per cent, giving an average for the three pickings of 29 per cent. But since another sample of 50 pounds of seed cotton made up of equal weights from each of the three pickings yielded only 26 per cent of lint, it is deemed fair to take 27.5 per cent, the average of these two results (29 and 26), as the closest possible approximation to the average lint percentage for the entire product from this field, very little of the total having been ginned at this writing.

[a] Mr. Argyle McLachlan early in the summer made a special study of the plants in the 4-acre field with respect to fruiting branches. He found that the first fruiting branch was developed at the ninth to fourteenth node from the base of the stem as compared with the thirteenth to seventeenth node in a planting of imported seed of the Mit Afifi variety. On thirty representative plants from different parts of the field the average lowest node at which a fruiting branch developed was the tenth. It has been pointed out by Mr. Cook that ability to develop fruiting branches at low nodes of the stem, and hence to set a "bottom crop," must considerably increase the earliness and yield of a cotton plant.

The type of plant characteristic of the Yuma variety is described in Mr. McLachlan's report as follows: "The plants are 6 to 8 feet tall with a leading main stem, 5 or 6 vegetative branches nearly as long as the axis but loaded with fruit and consequently spreading at an angle of 50 to 60 degrees, and above them on the axis pendent fruiting branches—a plant of symmetrical, broad-spreading, inverted-kite shape."

leaves were large, comparatively dull green, and usually three lobed. Even when five lobed the leaves were considerably longer than broad, owing to the great length of the middle lobe. The bracts of the involucre were exceptionally large and more or less connate at the base, and the bolls were long and taper pointed (Pl. III). The bolls opened early and completely and there was a somewhat marked tendency to drop the ripe seed cotton. The seeds were generally large for an Egyptian type of cotton and bore a greater amount of fuzz than is usually the case with seed of Mit Afifi cotton as grown in Egypt. The fiber was of fair length (ranging from 1¼ to 1$\frac{7}{16}$ inches, averaging probably 1⅜), of satisfactory strength and fineness, and of a pale-brown color, intermediate between that of the Nubari and that of the Jannovitch varieties, as represented by samples imported from Egypt. (See footnote *b*, p. 11.)

The strength and fineness of the lint were tested by Mr. L. H. Dewey, in charge of Fiber Investigations, the tests having been made on three samples of the bulk cotton from unselected plants in the general field. Two of the samples were from the second picking only, while the third sample was made up of equal parts from the first, second, and third pickings. Fiber ginned from the mixed seed cotton of the unselected plants in one of the progeny rows of this variety at Sacaton was also tested. The results of the tests were as follows:

TABLE I.—*Strength and diameter of fiber of the Yuma variety of acclimatized Egyptian cotton grown at Yuma and at Sacaton, Ariz., in 1909.*

Sample.	Breaking strength.		Diameter.	
	Average.	Variation.	Average.	Variation.
Field at Yuma:	*Grams.*	*Grams.*	*Microns.*	*Microns.*
Second picking only	6	4 - 9.5	24	18.5-30
	7	4 -11	24.5	19 -30
First three pickings, equally mixed	5.5	4 - 8.5	27	22.5-33.5
Progeny row at Sacaton	7.3	4.5-11	25.3	22.5-33.5

PERFORMANCE OF NEARLY RELATED TYPES.

Tests made in 1909 of two other types (Nos. 380 and 384) closely related to the Yuma variety (No. 382) are of interest as showing the general excellence of this group. Both of these types are derived from the same individual selection of 1906 which was the progenitor of the Yuma variety. The progenitor of each was an individual selection made in the same progeny row of 1907 in which plant 382 was selected. The progenies of the two selections of 1907 were grown in rows in the breeding nursery at Yuma in 1908, and the bulk seed from the unselected plants in each of these rows was used for the plantings in 1909. One of these types (No. 384) was planted

near the town of El Centro, in the Imperial Valley, California. The plants were very uniform in branching habit and foliage and showed only Egyptian characters, but one aberrant individual having been found among the fifty or more plants in this plat. The fiber was long, silky, and very strong—the best fiber of the Egyptian type produced in the Imperial Valley in 1909. The other type (No. 380) was planted in a test row at Yuma. The plants throughout the row were productive and had long, pointed bolls and large bracts similar to those of the Yuma variety. The seeds were generally smooth; the fiber averaged 1⅝ inches in length and was silky, very strong, and light colored.

PROBABLE MUTATIVE ORIGIN OF THE YUMA VARIETY.

The "Yuma" variety, type No. 382, was derived from imported seed of the Mit Afifi Egyptian variety. Most of the strains which have descended from the same original lot of seed are still typically Mit Afifi in all their characters, as was evident from comparison with plants grown from newly imported seed of that variety in 1908 and 1909. Nevertheless, this particular type now shows little resemblance to the parent variety. In the color of the lint it resembles more nearly the Jannovitch variety. It is especially remarkable for the long, taper-pointed bolls (Pl. III), which are much like those of the Abbasi variety and are in marked contrast to the short, blunt bolls of typical Mit Afifi (Pl. II). The manner of growth of the plants, the characters of the foliage, and the large involucre bracts are also diagnostic. The vegetative characters and the peculiarities of the seed and fiber have recurred with conspicuous regularity wherever seed of this variety or of nearly related types has been planted. The distinctiveness of the characters and their remarkable uniformity indicate that the variety originated as a mutation.[a] The history of such Egyptian varieties as Abbasi and Jannovitch, which are reported in Egypt to have developed from the widely grown and older Mit Afifi variety, makes it altogether probable that

[a] The peculiar branching habit and foliage of the plants were not especially noticed until 1908, when progeny row No. 382 was observed to stand out very distinctively from all other rows in the breeding nursery. Yet the large size of the bolls was noted as early as 1906 in the individual selection of that year, from which this variety is descended. This, together with the close resemblance in the characters of the related type No. 380 (descended from the same individual selection of 1906 which was the progenitor of the Yuma variety), indicates that the mutation occurred at least as long ago as 1906. The incompleteness of the records for the earlier years of this breeding work makes it impossible to determine whether the actual mutation occurred earlier than 1906. It is possible, although not probable, that it was present as an admixture in the Mit Afifi seed imported from Egypt with which the work was begun in 1902.

they originated as mutations from that variety in the same manner as the Yuma variety in this country.

THE SOMERTON VARIETY.

Type No. 370, here designated the "Somerton" variety, is remarkable for the sharply defined characters of the plants and bolls, and is like the Yuma variety in the great uniformity manifested in these respects. It has not yet been adequately tested on a field scale, but the progeny rows grown at Yuma and at Sacaton in 1909 showed it to be a very distinct and definite type. It is being tested in field plantings in 1910 in comparison with the Yuma variety.

HISTORY OF THE VARIETY PREVIOUS TO 1909.

The ancestry of the Somerton variety was similar to that of the preceding down to the year 1905, when the individual plant selection from which the Somerton variety is derived was made in the breeding nursery at Carlsbad, N. Mex. This plant was fairly productive and very early ripening and had small bolls and smooth seeds well covered with lint (percentage, 33). The fiber was fairly uniform in length, with an average of fully 1½ inches; it was brown in color, strong, and very fine. In the 1906 progeny row at Yuma planted with seed grown from this plant, the selected individual which was the progenitor of the Somerton variety was a small, fairly well-shaped, very productive, and early-ripening plant which had medium-sized bolls and smooth seeds well furnished with lint (percentage, 30.5). The fiber was 1½ inches long, very uniform, light brown in color, strong, and very fine. The 1907 progeny row from this plant was characterized by exceptionally early ripening. One of the individual selections made in this row, No. 370, was the immediate progenitor of the variety. It was an extremely productive plant, but the percentage of lint was only 26.5. The bolls were large[a] and the fiber was more than 1½ inches in length, uniform, fine, fairly strong, and cream colored.

Progeny row No. 370 contained in 1908 only 1.5 per cent of hybrids, a remarkably small proportion as compared with most of the other rows in the breeding nursery that year. (See footnote *b*, page 12.) The plants in this row were large and very productive, with a well-developed main stem surpassing the longest of the limbs. The latter were spreading or ascending. The bolls were large and

[a] It will be noted that while the 1905 selection had small bolls and the 1906 plant only medium-sized bolls, the 1907 progenitor of this variety had large bolls. While the bolls were increasing in size from year to year, the percentage of lint was diminishing from 33 per cent in 1905 to 30.5 per cent in 1906 and 26.5 in 1907. (In regard to the decreased lint percentage, see p. 17.)

remarkably sharp pointed. The seed cotton from the unselected plants in this row was picked and ginned together. The resulting lint was light brown in color; that from the first two pickings was classed by Mr. John A. Walker as "fine and strong" and that from the third as "strictly fine, silky, and extra strong." In length of fiber the first picking averaged $1\frac{3}{8}$ inches, the second ranged from $1\frac{3}{8}$ to $1\frac{7}{16}$ inches, and the third picking ranged from $1\frac{7}{16}$ to $1\frac{1}{2}$ inches. The excellent luster of the fiber in this row was noted in the field.

The seed cotton from the ten individual selections of 1908 was carefully compared. In seven of these the fiber was a little lighter colored than imported Nubari cotton, in two the fiber was slightly darker than imported Jannovitch, and in one the fiber was the same color as Jannovitch. The extreme range of length among these ten selections was from $1\frac{1}{4}$ to $1\frac{5}{8}$ inches, but the fiber was generally at least $1\frac{7}{16}$ inches long. The average strength was inferior to that of the selections from most of the other progeny rows of 1908. The general appearance of the fiber was very similar in the ten selections and indicated a distinct and uniform type. There was a strong tendency to smooth seeds.

EXPERIMENTS IN 1909.

Eight of the selections from progeny row No. 370 of 1908 were grown in progeny rows in 1909, six at Yuma and two at Sacaton. The rows at Yuma when inspected by Mr. McLachlan on July 6 showed a higher degree of uniformity and a more distinctive type of plant than any other group of progeny rows in the breeding nursery. Only two of the rows showed any trace of contamination; one contained a single probable hybrid and another had two suspicious-looking plants. The plants were bushy, large in diameter, with five to eight limbs nearly as long as the main stem, the internodes of which were unusually short. The leaves were exceptionally large and were usually broader than long. They were five lobed, with deep clefts between the lobes.[a] On July 23, when first inspected by the writer, the plants in all the rows had an exceptionally vigorous appearance and were distinguished by the unusually bright green color of the foliage. The two progeny rows at Sacaton, inspected August 3, showed the same type of plant and the same high degree of uniformity as the rows at Yuma. There were no obvious hybrids and only one suspicious-looking individual in each row.

On September 23 the plants in the six rows at Yuma had grown very large and were ripening late. The fruiting branches were set well toward the base of the plant and were well furnished with bolls.

[a] A somewhat similar habit and type of foliage characterized the plants grown at Yuma in 1909 from imported seed of the Nubari variety.

The seeds were generally smooth and rather poorly furnished with lint.[a] Individual selections were finally made in only two of the rows, the fiber in the other rows being too scanty and also inferior in length. Numerous selections were made in the two rows at Sacaton, in both of which the plants were characterized by high average fertility. The total number of individual selections of the Somerton variety made in 1909 was twelve at Yuma and eighteen at Sacaton.

The seed cotton from all of the unselected plants in one of the progeny rows at Sacaton was picked and ginned together. The lint was light brown, corresponding in color with imported fiber of the Nubari variety. The strength and diameter of the fiber were tested by Mr. L. H. Dewey, who reported the average breaking strength as 6.3 grams (variation 3.6 to 11.5 grams) and the average diameter as 23 microns (variation 18.7 to 30 microns). This diameter indicates a finer fiber than is shown by the fiber tests of the Yuma variety as reported in Table I (p. 18).

Seed from the unselected plants in progeny row No. 370 of 1908 was planted in 1909 at Yuma, Ariz., and at Brawley, in the Imperial Valley, California. In the small planting at Yuma the plants were of good average fertility, with generally large bolls and smooth seeds. The fiber was satisfactory in length, reaching 1⅝ inches on many plants and falling below 1¼ inches on hardly any. It was of good strength and medium fineness. In the 1-acre field planted with this seed at Brawley the plants were very uniform in appearance, and, with the exception of four hybrid individuals, showed only pure Egyptian characters. The fruiting branches, which were well furnished with bolls, were developed at low nodes on the stem. The bolls were large.

CHARACTERS OF THE PLANTS AND FIBER.

The Somerton variety as exemplified in the progeny rows at Yuma and Sacaton in 1909 is characterized by a great spread of branches, numerous long limbs, and long fruiting branches which are developed well toward the base of the plant and bear numerous bolls. The plants at about the time they begin to blossom have a symmetrical, rounded, bushy appearance and are exceedingly leafy. The large leaves are of a brighter green color and of softer texture than in the Yuma variety. They are usually five lobed and broader than long, while in the Yuma variety they are generally three lobed and considerably longer than broad. The bolls (Pl. IV), which resemble

[a] The average percentage of lint obtained by ginning the seed cotton from the thirty individual selections of the Somerton variety made at Yuma and Sacaton was 25.1 per cent, as compared with 26.7 per cent for the thirty-nine individual selections of the Yuma variety and 29.9 per cent for the eight selections of strains Nos. 360 and 362.

hose of the Abbasi Egyptian variety, are long and taper to an extremely sharp point, sharper than in the Yuma variety. The seeds have a strong tendency to be smooth and are frequently devoid of even the tuft of green or brown fuzz at each end which characterizes the seeds of the Mit Afifi variety in Egypt, while in the Yuma variety the sides of the seeds are usually partly covered with fuzz. The lint is very fine, but its percentage is less than in the Yuma variety. In color it is usually darker, varying from that of the Jannovitch to that of the Nubari variety. It shows about the same range of length as that of the Yuma variety.

PERFORMANCE OF A NEARLY RELATED TYPE.

Seed from another individual selection from the same progeny row of 1907 in which plant No. 370 was selected was grown at Yuma in 1908. Seed from all the unselected plants in the 1908 row was picked together and was used for planting a small plat in the neighborhood of Los Angeles, Cal., in 1909, alongside a similar planting of imported seed of the Mit Afifi variety.[a] The plants made only a small growth, produced comparatively few bolls, and ripened very late. On September 13, when none of the bolls had yet opened, no difference could be detected between the plants from the acclimatized and those from the imported seed, but in the quality of the fiber produced, the acclimatized ultimately proved very superior. The fiber was fine and silky and excelled in strength any other cotton of the Egyptian type grown in the Southwest in 1909. The average breaking strength, as reported by Mr. L. H. Dewey, was 8 grams (variation from 4 to 12 grams), and the average diameter 25 microns. As compared with this the fiber produced by the plants from the newly imported Mit Afifi seed in the same field was decidedly weaker and coarser, its average breaking strength being 6.8 grams (variation from 4 to 14.8 grams) and its average diameter being 30.6 microns.

PROBABLE MUTATIVE ORIGIN OF THE SOMERTON VARIETY.

Like the Yuma variety the Somerton variety is very distinct from the Mit Afifi stock with which this breeding work was begun and shows a high degree of prepotency, as evidenced by the remarkable uniformity which it has maintained notwithstanding abundant opportunities for crossing with other types. These facts give good

[a] This planting near Los Angeles, under the direction of Mr. O. F. Cook, was made to ascertain the effect of very different climatic conditions upon the habit of the plants and upon the expression of diversity in a stock that had been acclimatized in the Colorado River region as compared with newly imported seed. It was realized, of course, that the conditions in that part of California are not favorable to cotton culture on a commercial scale.

ground for the belief that it has originated as a mutation. It is possible that the mutation occurred in 1907, since the breeding records show that the 1905 ancestor of the strain had small bolls and the 1906 ancestor medium-sized bolls. The 1907 progenitor, which was the first recorded as having large bolls, may well have been the original mutant, but unfortunately no detailed description was made of the vegetative characters of this plant. The plants of a nearly related type grown near Los Angeles (p. 23) were so unlike those in any planting of Egyptian types of cotton that has been made in the Colorado River region,[a] that it was impossible to decide whether this stock shares the vegetative characters of the Somerton variety. If it had been grown under similar conditions and had exhibited the same characteristics, ample evidence would have been afforded that the mutation must have occurred at least as early as 1906.

STRAINS NOS. 360, 361, AND 362.

ORIGIN OF THE GROUP.

The group of strains Nos. 360, 361, and 362, like the Yuma and Somerton varieties, was derived from an individual selection made at Carlsbad, N. Mex., in 1905, in a part of the breeding nursery where the numbers of the progeny rows had been lost. The ancestry of the group previous to 1905 is therefore unrecorded except that each strain was derived from the same lot of imported Mit Afifi seed used in beginning the breeding work in 1902, from which all the varieties and strains described in this paper originated. An individual selection in the progeny row from the Carlsbad plant grown at Yuma in 1906 is the common ancestor of this group of strains. The plants representing the progeny of the individual selected in 1906, grown in a row at Yuma in 1907, were noted as being uniformly excellent. Three individual selections of that year, numbered as above, are the direct progenitors of the three corresponding strains.

STRAIN NO. 360.

Selection No. 360 of 1907 was characterized by a satisfactory percentage of lint (30 per cent) and by fiber that was fully 1½ inches long, uniform in length, fine, and of a good brown color, but rather inferior in strength. The 1908 progeny row from this plant contained about 11 per cent of hybrids. The remaining plants were

[a] The plants grown near Los Angeles, both from the acclimatized strain and from imported Mit Afifi seed, were small, and they had few and short limbs; they were conspicuously hairy and had a great deal of red color in the stems and involucres. The bracts were broad, cordate, and deeply toothed. The calyx was distinctly toothed, a character usually peculiar to Upland as distinguished from Egyptian types. The stigmas were exceptionally short.

uniform and were typically Mit Afifi in their characters. They were productive, ripened early, and produced fiber that was distinctly brown in color. The seed cotton from the unselected plants in this row was picked and ginned together. The lint had an average length of 1⅜ inches in the first picking and ranged from 1⅜ to 1½ inches in the second picking. The strength and color were very satisfactory in both pickings. Three individual selections were made in this row, and the seed was planted in progeny rows in 1909, two at Yuma and one at Sacaton. When examined July 6 one of the rows at Yuma contained two and the other four unmistakable hybrid individuals, and there was considerable diversity among the remaining plants. The row at Sacaton, inspected August 3, contained no obvious hybrids, but the plants were generally infertile, and the row was discarded. In September one of the rows at Yuma was decidedly inferior in the average length, strength, and fineness of the fiber, and no selections were made; only one individual selection was made in the other row at Yuma.

The seed cotton from the unselected plants in progeny row No. 360 of 1908 was picked and ginned together and the seed was planted at Holtville, in the Imperial Valley, California, in 1909. The soil was very sandy and the seed was planted late, consequently the yield was small. Nevertheless, many of the plants showed a strong tendency to produce a "bottom crop," developing fruiting branches at low nodes on the stem. On a good percentage of the plants the fiber was satisfactory in length and strength. There was considerable diversity in the appearance and vegetative characters of the plants, and a large number of hybrids and otherwise aberrant plants were removed at the end of July.

STRAIN NO. 361.

History.—Individual selection No. 361 of 1907 was a much more productive plant than No. 360, but otherwise greatly resembled it. The seeds were abundantly furnished with lint, the percentage being 32. The fiber had all the characters of a good Mit Afifi and was very fine, strong, and of a good brown color. The length exceeded 1½ inches and was very uniform. In 1908 the progeny row from this plant contained about 6 per cent of hybrids. It was one of the most uniformly fruitful and early-ripening rows in the breeding nursery. The fiber was of typical Mit Afifi character, and was highly satisfactory in fineness, color, and length, although the uniformity of length was somewhat disappointing. The percentage of lint was good. All seed from the unselected plants in this row was picked and ginned together. Mr. John A. Walker reported on the lint from the first picking that it has a "distinctly brown color, even throughout, showing very little white, giving it a greater resemblance to regular Egyptian

GENERAL CHARACTERISTICS OF STRAINS NOS. 360, 361, AND 362.

The plants of strains Nos. 360, 361, and 362 grown in progeny rows at Yuma in 1909 had an open habit (Pl. I, fig. 1) with a few long, upright, slender limbs nearly equaling the main stem in length; the fruiting branches were long and slender, bearing comparatively few bolls, and generally had a very long basal internode;[a] the foliage rather sparse; the bolls short, rounded, and with a blunt tip (typical Mit Afifi bolls, see Pl. II); the seeds smooth or partly covered with fuzz; and the fiber generally short and strong, fine, and nearly as brown in color as imported Mit Afifi fiber. The percentage of lint was much higher than in the Yuma and Somerton varieties, 25 pounds of seed cotton from the "bulk selections" in the 3-acre field of strain 361 having yielded 31.6 per cent of lint.[b]

These strains constitute a uniform type which shows no marked departure from typical Mit Afifi cotton as grown in Arizona from imported seed, except that the plants are more productive and develop fruiting branches at lower nodes on the stem, open their bolls earlier, and produce lint of better quality. The high degree of uniformity exhibited by the plants in the 3-acre field of strain 361 at Yuma in 1909 indicates a considerable degree of prepotency, since the progeny row which produced this seed in 1908 was situated in the breeding nursery among other rows of very different type, most of which contained numerous mybrids (footnote *b*, p. 12).

IMPORTED SEED OF EGYPTIAN VARIETIES TESTED IN 1909.

As a check on the progress of the acclimatization and selection and in order to compare the amount and kinds of diversity shown by the plants from newly imported seed with that of the acclimatized and selected stocks, seed of the six leading Egyptian varieties (Mit Afifi, Nubari, Jannovitch, Ashmuni, Abbasi, and Sultani) was planted in alternate rows in the Yuma Valley and at Sacaton, Ariz. Larger plantings (one-half acre to 1 acre) of the first four varieties were also made in the Yuma Valley. A plat of imported Mit Afifi was

[a] This rather undesirable branching habit does not appear to be inherent in these strains, but seems to be due mainly to the unfavorable situation of these particular rows, which suffered several times during the season from lack of moisture on account of the competition of a neighboring row of trees. In the row which had the most favorable moisture conditions the plants were much more productive, with fruiting branches developed well toward the base and usually bearing five or six bolls each. In this row the bolls were larger than in the others.

[b] Mr. Argyle McLachlan found that 100 delinted seeds of strain 361 weighed 11.75 grams, while the same number of seeds from a sample of imported Mit Afifi weighed only 10 grams. If the seeds weighed no more than the imported (see p. 17), the lint percentage of strain 361 would therefore have been 35.3 instead of 31.6.

also grown alongside a planting of a select acclimatized stock derived from the same variety at Glendale, near Los Angeles, Cal. (See p. 23.)

The imported varieties differed widely in the amount of diversity shown, this being least in the Mit Afifi and Nubari varieties and greatest in Ashmuni. The Mit Afifi and Nubari varieties showed a high degree of uniformity, indicating that the seed received from Egypt was the result of careful selection in that country. The Mit Afifi, as in all previous plantings of imported seed of that variety, at all places where the comparative plantings were made, showed itself very inferior to the acclimatized and selected stocks in yield, earliness, and quality of the fiber. On the other hand, the Nubari, although by no means equaling the improved strains which have resulted from several years of acclimatization and selection in the Southwest, was decidedly superior in all these respects to any other planting of newly imported seed which has been made in that region. The yield from one-half acre of this variety was 514 pounds of seed cotton, which was equivalent to 290 pounds of lint per acre, the percentage of lint being 28.1.

MISCELLANEOUS EXPERIMENTS IN 1909.

In addition to the plant-breeding experiments and the field tests of acclimatized and imported stocks, a number of other experimental plantings were made near Yuma, Ariz.

Progeny of first-generation hybrids.—Progeny rows of several first-generation Upland-Egyptian hybrids selected in the breeding nursery of 1908 (see footnote *b*, p. 12) were grown. It was observed in 1908 that these first-generation hybrids, when compared with the pure Egyptian plants in the rows in which they occurred, were very superior in fruitfulness, size of bolls, and in the abundance, length, and strength of the fiber. The progenies of the different individuals in 1909 showed considerable difference in the amount of diversity and in the degree in which the characters of the Egyptian or of the Upland parent predominated. None of the plants in any of the rows came near equaling the parent selections in productiveness or in the quality of the fiber. Some of the first-generation hybrid parents had very smooth seeds and others had completely fuzzy seeds. As a rule, the progenies in 1909 showed no uniformity in their inheritance of this character; many fuzzy-seeded offspring were from smooth-seeded parents, and vice versa. An examination of these hybrid progeny rows gave no indication of the likelihood that a superior strain could be developed by this method, and no selections were made in the second generation.

Production of first-generation hybrids.—Under the direction of Mr. O. F. Cook, Egyptian cotton was planted in rows alternating

with various Upland varieties in order to test the possibility of securing in this manner a stock of first-generation hybrid seed for commercial planting.[a] The early flowering of most of the Upland varieties, as compared with the Egyptian, indicated that to use this method successfully it might be necessary to select a late-flowering Upland variety for the alternate plantings or else to plant the Upland cotton later than the Egyptian.

Seed selection.—Another experiment, carried on by Mr. Argyle McLachlan, was the planting in separate rows of the different types of seed selected from various imported and acclimatized lots, in order to determine the possible advantage of sorting by hand cotton seed that has become mixed by hybridization, and thus to eliminate aberrant types before planting, thereby gaining greater uniformity in the crop and reducing the opportunity for further crossing.

Different dates of planting.—Row plantings of a single acclimatized stock were made on successive dates throughout the spring in order to compare the effect of early with that of late planting under otherwise uniform conditions upon the fruitfulness and lint qualities of the plants, and to ascertain the best time for putting in the seed. For various reasons this experiment gave no conclusive results, but the matter is an important one and will be made the subject of further experimentation. All the evidence so far obtained points to the advantage of planting Egyptian cotton in the Colorado River region as early in the spring as the weather will permit.

Seed from different pickings.—Seed from the different pickings of several of the acclimatized stocks was planted in rows in order to determine if possible whether the early or the late ripened seed is the most desirable for planting. Only negative results were obtained, none of the three pickings appearing to give generally better results than either of the others, but it is not considered that this problem has been finally solved.

Irrigation.—The conditions in 1909 with regard to the supply of water for irrigation were so unfavorable that no special experiments could be carried out to determine the best method of irrigating Egyptian cotton. There is no question that the yield, uniformity, and quality of the fiber, especially in respect to length and strength, depend in a high degree upon the manner in which the plants are irrigated. This is considered the most important cultural problem remaining to be solved in connection with the production of this crop in the Southwest.

[a] In a paper entitled "Suppressed and Intensified Characters in Cotton Hybrids," Bulletin 147, Bureau of Plant Industry, United States Department of Agriculture, pp. 15–16, Mr. Cook calls attention to the possible commercial utilization of the superior qualities of first-generation hybrids of Egyptian with Upland cotton.

PRESENT COMMERCIAL STATUS OF EGYPTIAN COTTON IN THE UNITED STATES.

During the latter part of 1909 and the early months of 1910 all types of cotton commanded unusually high prices. The condition of the long-staple cotton market was especially abnormal owing to the operation of a number of independent causes. The advance of the boll weevil in the cotton belt of the South has led to a feeling of uncertainty in the localities which furnish the bulk of our supply of long-staple Upland cotton. Furthermore, the 1909 crop in Egypt was an exceptionally small one, and from all reports the quality of the fiber was unusually poor. Various explanations are offered for the disquieting state of affairs that exists in Egypt. It is widely believed that the construction of the great dam at Assuan, in upper Egypt, and of "high line" canals, with the consequent abundance of irrigating water and increased opportunity for seepage, has resulted in raising the water table throughout the cotton-growing provinces of the Delta to a point that seriously injures the deep-rooted cotton plants.

TABLE II.—*Average prices of Good Fair Egyptian and Middling Upland cottons on the Boston market for each month from January to October, 1909.*[a]

Month.	Average price per pound. Good Fair Egyptian.	Average price per pound. Middling Upland.	Month.	Average price per pound. Good Fair Egyptian.	Average price per pound. Middling Upland.
	Cents.	*Cents.*		*Cents.*	*Cents.*
January	17.0	9.9	June	18.5	11.5
February	16.5	9.9	July	19.9	12.9
March	16.0	9.9	August	19.9	12.7
April	16.6	10.5	September	20.2	13.2
May	18.0	11.3	October	22.0	14.4

[a] The average prices of Egyptian and Middling Upland cottons on the Boston and Liverpool markets during the ten years from 1898 to 1907, inclusive, are stated in Bulletin 128, Bureau of Plant Industry, p. 25, tables 4 and 5. Prices during 1908 are discussed in Circular 29, Bureau of Plant Industry, pp. 5 and 6.

TABLE III.—*Average prices of different grades of Egyptian and of Middling Upland cotton on the Boston market for each month from November, 1909, to July, 1910.*[a]

Month and year.	Average price per pound. Egyptian. Low grades.	Egyptian. Current.	Egyptian. Good grades.	Egyptian. High grades.	Middling Upland.
	Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*
November, 1909	19 -22¾	20½-23¾	21¾-25½	23 -27¼	15 -15⅝
December, 1909	22½-25½	24 -27½	26 -29½	27¾-31	15 -15⅝
January, 1910	21 -26⅝	25⅝-28⅝	27⅝-30⅝	29¾-32½	15 -16⅜
February, 1910	22 -27	26 -32	28½-33	31¾-35¼	15 1/16-15 7/16
March, 1910	22¼-28½	27¼-33½	32½-34½	33½-36⅞	15 7/16-15 13/16
April, 1910	20½-27⅞	23¾-32⅞	28½-33¾	31½-36⅞	15 1/16-15 11/16
May, 1910	19¾-22¾	23½-26½	26¾-30¾	29¾-33	15 5/16-15 13/16
June, 1910	17¾-22¾	19¾-26½	21¾-30¾	22¾-33	14¾-15½
July, 1910	17½-20½	19½-21¾	20¾-22¾	21¾-24½	15½-16

[a] The prices for each month are the minimum and the maximum of the weekly prices for each grade as quoted in the Commercial Bulletin, published at Boston.

It would be unwise to rely upon a maintenance of the recent very high level of prices. During the ten years from 1898 to 1907, inclusive, the average price on the Boston market of all grades of Egyptian cotton imported was 15.3 cents, as compared with 9.5 cents for Middling Upland. During 1908 the average price of Egyptian cotton on the same market was 18.07 cents, as compared with 11.11 cents for Middling Upland. It should be noted, however, that these prices cover the total quantity of Egyptian cotton imported, much of which belongs to very inferior grades. Fiber of a quality such as experiments have demonstrated can be produced in the Southwest would be expected to command a premium of several cents over the average.

The total imports of Egyptian cotton into the United States during the calendar year 1909 amounted to 72,617,893 pounds, valued at $12,101,000, as compared with 61,511,723 pounds, valued at $11,560,009, in 1908.

CONCLUSION.

In summing up the most important results of the breeding work with Egyptian cotton in 1909, it is noted that the diversity caused largely by crossing with other types of cotton, which in 1908 seemed to seriously threaten the future of the acclimatized stock, has to a great extent disappeared. This is doubtless partly due to the planting of carefully selected types. The most promising of these is apparently a mutation and shows a strong tendency to be prepotent; in other words, to maintain its uniformity even in the presence of opportunity for crossing with other stocks. The application of methods of eliminating hybrids and aberrant individuals before the plants begin to open their flowers which Mr. Cook has worked out as a result of his diversity studies has also greatly contributed to this result.

The breeding work of the past seven years has developed several superior strains and two very distinct varieties which are now ready for testing on a field scale. The two varieties—the Yuma and the Somerton—developed from an imported stock of the Mit Afifi variety, represent a wide departure from the characteristic parent type. In their large, pointed bolls and lighter colored fiber they more nearly approach other Egyptian varieties, which are also believed to be derived from Mit Afifi and probably originated in the same manner as " sports " or " mutations." One of the new strains represents typical Mit Afifi in the shape of its bolls and in the deeper color and other characteristics of its fiber, but is notably superior to the average of that variety, at least as grown in the United States from imported seed. This strain, which was grown last year on a field scale, likewise exhibited a high degree of uniformity.

Experiments in 1909 with these well-marked new varieties indicate that transfer to a new locality having somewhat different climatic and soil conditions does not induce diversity to anything like the extent that results when newly imported seed or mixed seed of different acclimatized stocks is planted in new places. Thus the very distinct Yuma variety, which was first distinguished and very likely originated at Yuma, Ariz., maintained its superior uniformity, productiveness, and distinctive type of plants and of fiber when planted under the decidedly different conditions existing at Sacaton, Ariz., and in the Imperial Valley, California. The equally distinct Somerton variety, which also probably originated near Yuma, maintained its superiority to newly imported seed at Sacaton and at Los Angeles, Cal., although in the latter locality, which represents an extreme departure from the climatic conditions existing in the Yuma Valley, the general appearance of the plants was very different. It is therefore apparent that the difficulties of "local adjustment" or adaptation of an acclimatized strain to the varying climatic and soil conditions of different localities in the region in which the acclimatization has taken place are not likely to interfere seriously with the extensive utilization of selected types possessing a high degree of prepotency such as are described in this paper.

SUMMARY.

Several distinct and promising varieties and strains which have resulted from the acclimatization and breeding experiments with Egyptian cotton in the southwestern United States were tested on a field scale in the Colorado River region in 1909 and gave very favorable results in regard to the quality and uniformity of the fiber produced.

The results of the season's work showed that by planting carefully selected types and by "roguing out" the markedly aberrant individuals early in the summer the degree of uniformity can be attained which is demanded by the market for this class of cotton.

Diversity can be still further controlled and the fruitfulness of the plants maintained by avoiding extremely light and extremely heavy types of soil and by managing irrigation so that the plants are not exposed to alternations of severe drought and excessive moisture.

Samples of the fiber produced in 1909 were submitted to a number of spinners and other experts, who were unanimous in pronouncing them equal in all respects to imported Egyptian cotton of corresponding grades.

Two of the best types (the Yuma and Somerton varieties) are so distinct from the Mit Afifi variety from which they have been derived as to warrant the belief that they are mutations and have originated

in the same manner as Abbasi, Jannovitch, and other superior types which have been developed in Egypt from the Mit Afifi variety.

A third type (strains 360, 361, and 362) resembles Mit Afifi in all characters of the plants, bolls, and fiber, but the plants are much more productive and produce fiber of better quality than those grown in the same region from imported seed. This type is to be regarded as an acclimatized and improved Mit Afifi rather than a new variety.

The Yuma variety was tested in a field of 4 acres near Yuma, Ariz., in 1909, and showed a very satisfactory degree of uniformity in the productiveness and habit of the plants and in the quality of the fiber. It is characterized by a strong tendency to develop a stout main stem greatly surpassing the limbs, and possesses long fruiting branches, long taper-pointed bolls, and strong, silky, cream-colored fiber, averaging about 1⅜ inches in length.

The Somerton variety resembles the preceding in the length of its bolls and in most of its fiber characters, but the bolls are more sharply pointed, the seeds generally smoother, the percentage of lint smaller, and the plants more bushy, with a greater development of large vegetative branches.

The group of strains Nos. 360, 361, and 362 constitutes a uniform type that is very different from the Yuma and Somerton varieties. The plants are of open habit, with several large limbs nearly equaling the main stem; short, plump, abruptly pointed bolls; and strong fiber of medium length (averaging 1¼ to 1⅜ inches). In color the fiber is almost as brown as that of imported Mit Afifi.

Other more or less distinct types have been developed, but are either less satisfactory or have not yet been sufficiently tested.

Imported seed of the principal Egyptian varieties was planted in 1909 in Arizona in the vicinity of Yuma and at Sacaton. The varieties differed greatly in the amount of individual diversity manifested. None of them equaled the acclimatized stocks in fruitfulness or in quality of the lint.

Progenies of a number of first-generation Egyptian-Upland hybrids were grown near Yuma. The second-generation plants showed excessive diversity of type, but none of them could compare with the first-generation parents in yield or in excellence of the fiber.

The imports of cotton from Egypt into the United States during the calendar year 1909 amounted to 72,617,893 pounds, valued at $12,101,000, as compared with 61,511,723 pounds, valued at $11,-560,009, in 1908.

PLATES.

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DESCRIPTION OF PLATES.

PLATE I. Fig. 1.—A fertile plant of acclimatized Egyptian cotton of the type characteristic of strains Nos. 360, 361, and 362, with several large ascending vegetative branches nearly as long as the main stem and bearing a considerable percentage of the bolls. Grown near Yuma, Ariz., in 1908. Fig. 2.—A plant of the Yuma variety of acclimatized Egyptian cotton with a tall, stout main stem bearing most of the bolls and with the vegetative branches much reduced. Grown near Yuma, Ariz., in 1908.

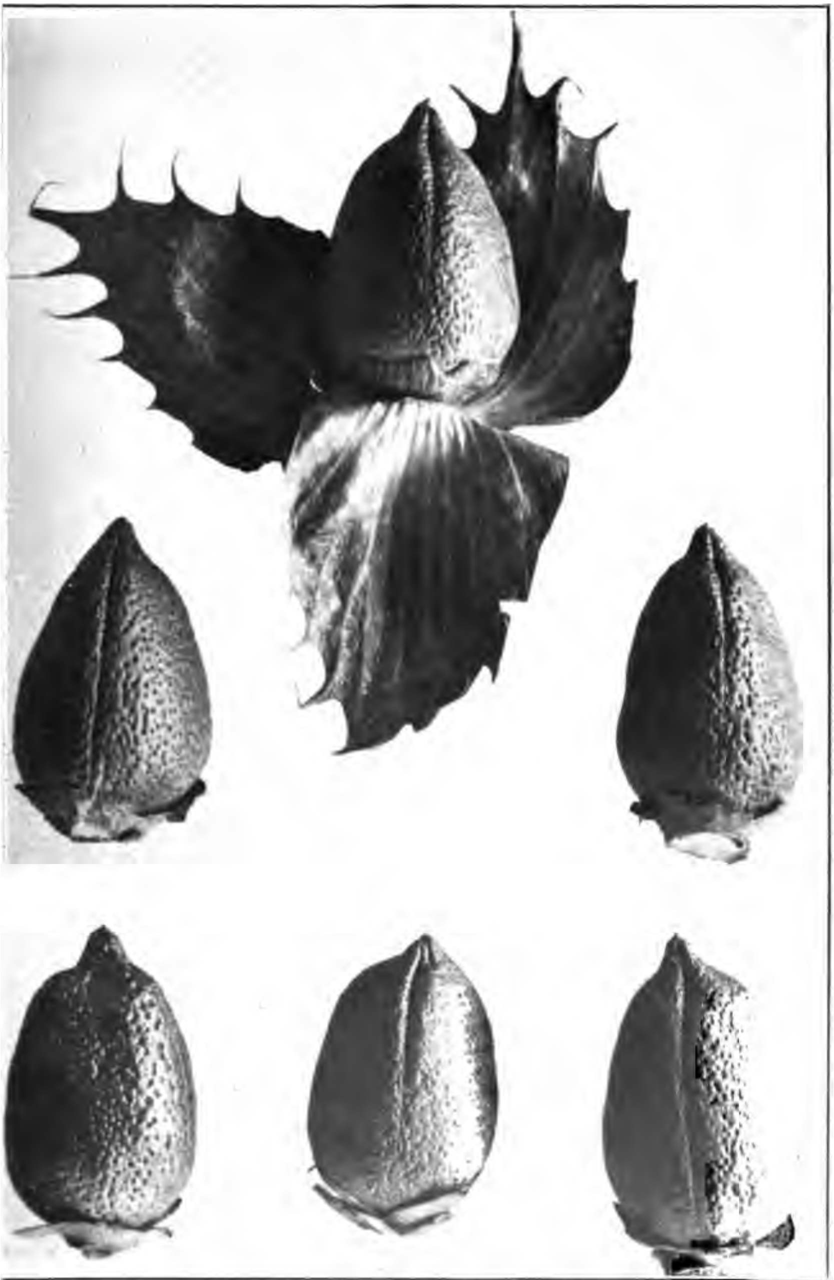
PLATE II. Typical bolls and bracts (natural size) of Mit Afifi Egyptian cotton grown from imported seed near Yuma, Ariz., in 1908.

PLATE III. Typical bolls and bracts (natural size) of the Yuma variety of acclimatized Egyptian cotton grown near Yuma, Ariz., in 1909. Note the larger and more pointed bolls as compared with typical Mit Afifi (Pl. II).

PLATE IV. Typical bolls and bracts (natural size) of the Somerton variety of acclimatized Egyptian cotton grown near Yuma, Ariz., in 1909. The bolls are more sharply pointed than in the Yuma variety (Pl. III).

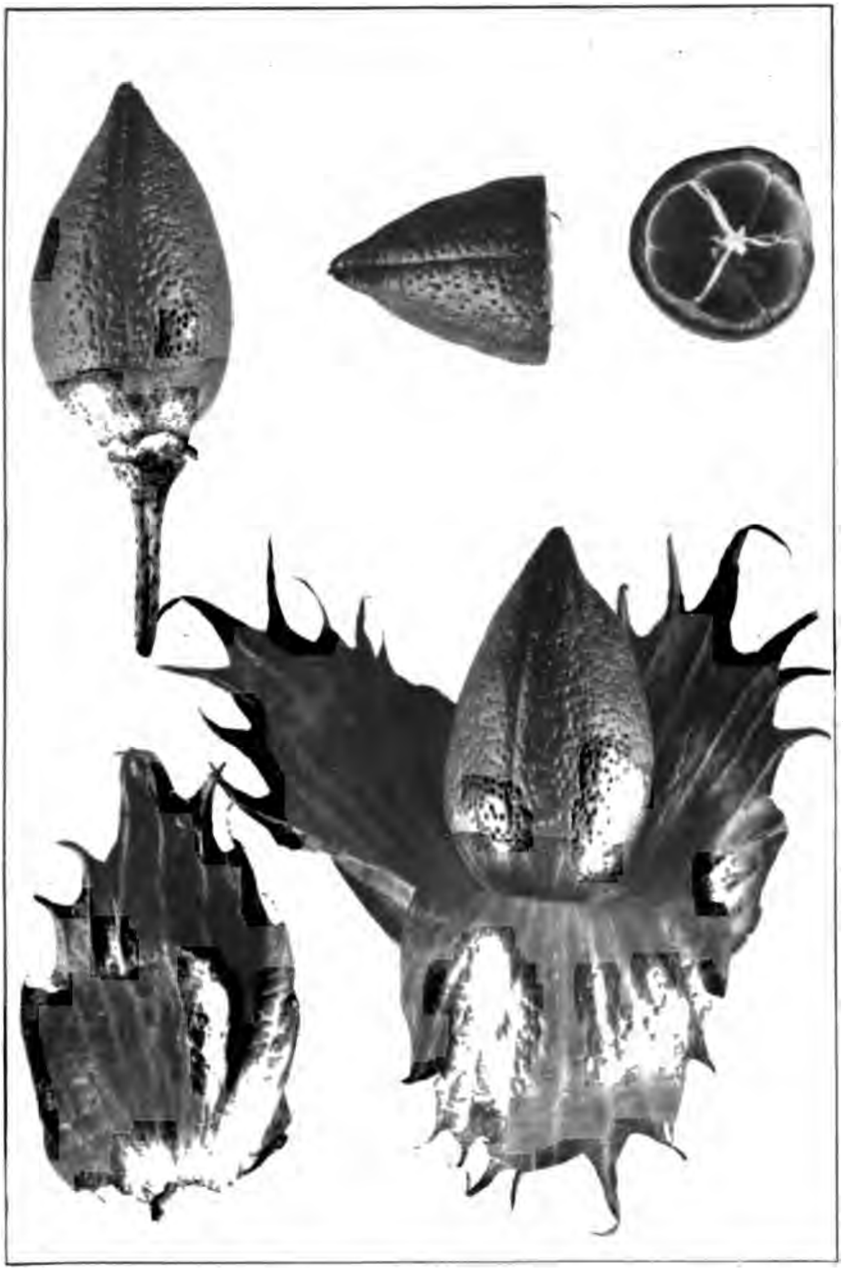
FIG. 1.—A FERTILE PLANT OF ACCLIMATIZED EGYPTIAN COTTON.

FIG. 2.—A PLANT OF THE YUMA VARIETY OF ACCLIMATIZED EGYPTIAN COTTON.



TYPICAL BOLLS AND BRACTS OF MIT AFIFI EGYPTIAN COTTON GROWN FROM IMPORTED SEED.

(Natural size.)

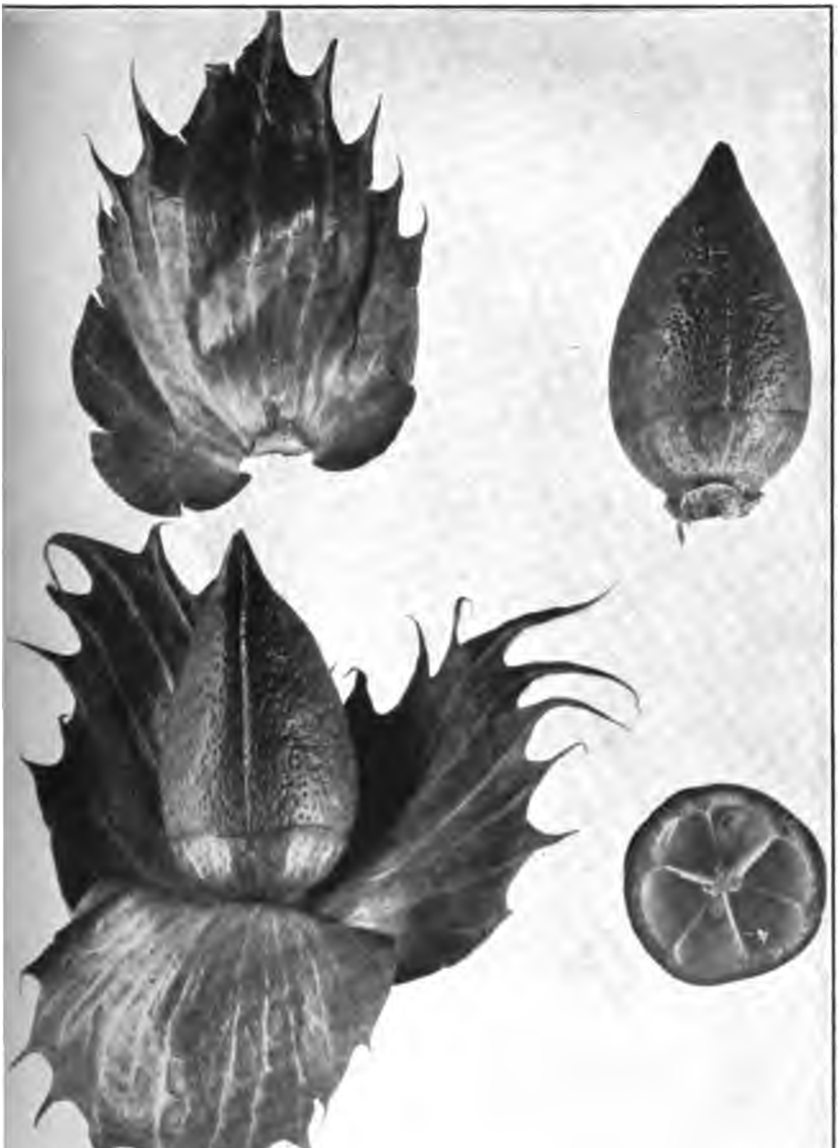


TYPICAL BOLLS AND BRACTS OF THE YUMA VARIETY OF ACCLIMATIZED EGYPTIAN COTTON.

(Natural size.)

TYPICAL BOLLS AND BRACTS OF THE YUMA VARIETY OF ACCLIMATIZED EGYPTIAN COTTON.

(Natural size.)



TYPICAL BOLLS AND BRACTS OF THE SOMERTON VARIETY OF ACCLIMATIZED EGYPTIAN COTTON.

(Natural size.)

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U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 201.
B. T. GALLOWAY, *Chief of Bureau.*

NATURAL VEGETATION AS AN INDICATOR OF THE CAPABILITIES OF LAND FOR CROP PRODUCTION IN THE GREAT PLAINS AREA.

BY

H. L. SHANTZ,

PHYSIOLOGIST, ALKALI AND DROUGHT RESISTANT PLANT BREEDING INVESTIGATIONS.

ISSUED MARCH 16, 1911.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

BUREAU OF PLANT INDUSTRY.

Chief of Bureau, BEVERLY T. GALLOWAY.
Assistant Chief of Bureau, WILLIAM A. TAYLOR.
Editor, J. E. ROCKWELL.
Chief Clerk, JAMES E. JONES.

ALKALI AND DROUGHT RESISTANT PLANT BREEDING INVESTIGATIONS.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., October 11, 1910.

Sir: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 201 of this Bureau the accompanying manuscript entitled "Natural Vegetation as an Indicator of the Capabilities of Land for Crop Production in the Great Plains Area," by Dr. H. L. Shantz, Physiologist, Alkali and Drought Resistant Plant Breeding Investigations, Bureau of Plant Industry.

Extensive tracts of land, including thousands of acres that are doubtless capable of producing crops, still remain unoccupied in the United States, especially west of the ninety-eighth meridian. In places where no attempts at tillage have yet been made the would-be settler or investor is often at a loss to know whether the land in view is adapted to a particular crop or even whether it has any agricultural value. In such places the character of the natural vegetation is usually studied as an index of its crop-producing possibilities, but mistakes are often made in using this indicator without sufficient consideration.

The object of the present paper is to show how the native plant cover can safely be used as a guide to probable crop production. As a result of investigations carried on during the past three years in the Great Plains area definite correlations have been determined between the different types of vegetation and the physical characteristics and crop possibilities of the land occupied by each type. Although most of the detailed investigations have been carried on in eastern Colorado, enough work has been done elsewhere to show that with comparatively little modification the results can be applied throughout the Great Plains area. When the correlations are worked out for a given region as carefully as has been done in the present instance, they should not only be useful as a means to land classification on a large scale, but they could be applied by farmers and other persons who have occasion to estimate the probable agricultural value of new land.

The author desires to acknowledge his indebtedness to Dr. L. J. Briggs, Physicist in Charge of the Physical Laboratory of the Bureau of Plant Industry, for much advice and assistance in the physical part of the investigations. In connection with the experimental work in the field Mr. E. C. Chilcott, Agriculturist in Charge of Dry-Land Agriculture Investigations, Bureau of Plant Industry, placed at the author's disposal the resources of the dry-land experiment farms in the Great Plains area. The Bureau of Soils has obligingly furnished chemical and mechanical analyses of numerous soil samples.

Respectfully,

G. HAROLD POWELL,
Acting Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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NATURAL VEGETATION AS AN INDICATOR OF THE CAPABILITIES OF LAND FOR CROP PRODUCTION IN THE GREAT PLAINS AREA.

INTRODUCTION.

Farmers and other persons who have occasion to examine new land in order to form a judgment of its agricultural value depend largely upon the natural vegetation, or plant covering, as an indicator of its crop-producing capabilities. But there are many possibilities of error in judging land upon this basis. Species that are closely related botanically and very similar in appearance may indicate quite different conditions of soil and climate. The popular names of plants are likely to cause confusion. Thus, the farmer who has learned in the Great Basin region that "greasewood" is an indicator of alkali land and that "sage brush" usually grows on land free from alkali will find, if he moves to southern Arizona or southeastern California, that the shrub there known as "greasewood" indicates absence of alkali, while the so-called "sage bushes" of that region grow on strongly alkali land. Furthermore, there is a general tendency to depend upon a single plant species as an indicator, while the investigations set forth in this bulletin show that the composition of the plant covering as a whole is a much more reliable basis for judging the crop-producing capabilities of land.

The chief object of the present paper is to show how these sources of error may be avoided and how new land may be classified readily and with reasonable accuracy on the basis of its natural vegetation. This paper is not a report of a land survey, but rather a discussion of methods which it is believed could be utilized to advantage in making such a survey, the methods being illustrated by application to a limited territory in the Great Plains area.

Too much emphasis can not be laid upon certain facts that have been clearly brought out in the course of these investigations: (1) Correlations between the natural plant cover and the crop-producing capabilities of land in a given area can be satisfactorily determined only after careful study of the different types of vegetation of the area in relation to their physical environments; (2) such correlations,

determined for some particular region, will need to be modified to a greater or less extent before they can be applied in another region where the physical conditions are different. When, as a result of sufficient investigation, correlations of this nature are determined for a given area, it is believed that they will afford a basis for classifying the land of that area more readily and at least as accurately as by any other known method.

In order to test and perfect the methods here described it was necessary to make a detailed study of the vegetation of some particular area in relation to the physical conditions, checking the observations by the study of such examples of actual crop production as exist on the different types of land. It was decided to begin work in the Great Plains area that lies between the ninety-eighth meridian and the Rocky Mountains, for this region contains the largest body of land in the United States having possible agricultural value on which the native plant covering is still undisturbed. A further advantage is the comparative uniformity of the climate throughout the area from the Canadian boundary on the north to the "Panhandle" of Texas on the south. The investigations thus far have been made chiefly in a portion of eastern Colorado, a region which is considered representative because of its central position and because its climatic conditions are almost as extreme as anywhere in the Great Plains. But enough data have been gathered in other portions of the Great Plains to make it fairly certain that with comparatively little modification the correlations shown will hold good throughout the area.

The work so far accomplished has brought out clearly that in this area the general conditions, whether favorable or unfavorable to crop production, are indicated by the character of the native plant cover. Land which bears a pure short-grass cover was found to be supplied with water in the surface foot or two of soil only, and usually even to that depth for but a brief period during spring and early summer. Land with a uniform cover of tall grasses was found to be supplied with water to a much greater depth and to offer conditions favorable for plant growth during a much longer season. As a connecting link between these two conditions a short-grass cover which supports a scattered growth of taller plants was found to indicate intermediate conditions as regards water supply.

The areas of greatest agricultural value one year with another are those marked by the presence of the wire-grass vegetation (p. 48). Of almost equal value are the areas characterized by those phases of the grama–buffalo-grass vegetation which are distinguished by the presence of a considerable quantity of Psoralea (p. 46) or of wire-grass (p. 47). Bunch-grass land (p. 54) is best for crops during especially

lry years, but is relatively the least productive during favorable rears. Typical short-grass land (grama–buffalo-grass association). 24) produces more than any other type during wet years, but is irst to fail in time of drought. Areas characterized by certain other types of vegetation (p. 60) were found to be unfit for agricultural purposes.

3ENERAL CONSIDERATIONS ON THE USE OF VEGETATION AS AN INDICATOR.

DIFFICULTY OF CORRELATING VEGETATION WITH ANY SINGLE FACTOR OF THE ENVIRONMENT.

The great difficulty of correlating vegetation with any single factor is shown by the vast difference of opinion among botanists as to which factors are of the greatest importance in controlling plant distribution.

Correlations with the physical or the chemical nature of the soil have often been successfully applied for a limited area, but without exception these correlations have failed to apply when extended to wider areas. The results of numerous attempts seem to prove that a strict correlation of vegetation with the physical or chemical nature of the soil is possible only when all other conditions of the habitat are comparatively uniform. When the climatic conditions and the physical condition (texture, water content, etc.) of the soil are uniform we should be able to correlate variation in the vegetation with differences in the chemical nature of the soil; on the other hand, when the climatic conditions and the chemical composition of the soil are uniform, the differences observed in the vegetation are probably due to inequalities in the physical nature of the soil. Variations, either physical or chemical, are of greatest importance when they approach the limit of favorable conditions. A correlation between vegetation and either the chemical or physical nature of the soil can be expected to apply only over a limited area where the other conditions are practically uniform. As soon as we move from one region to another the correlation between vegetation and soil type is at once broken down.[a] In the Great Plains region this is very clearly brought out by the following examples:

In eastern Colorado short-grass vegetation is correlated with a loam soil, wire-grass with sandy loam soil, and bunch-grass with sand soil. Here, under conditions of practically uniform rainfall, evaporation, etc., we have a close correlation between the vegetation and the soil types.

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[a] Thurmann, Julius. Essai de Phytostatique, 1849, p. 403. Warming, Eugenius. Ecology of Plants, 1909, pp. 69-70.

Again, in eastern Colorado, with a rainfall of from 15 to 18 inches, loam soil is covered with a comparatively pure short-grass cover; in west-central Kansas, with a rainfall of from 22 to 24 inches, loam soil is characterized by wire-grass vegetation; while in eastern Kansas, with a rainfall of from 26 to 30 inches, bunch-grass occurs on this type of soil. Here, under comparatively uniform soil conditions, a rather close correlation can be established between rainfall and vegetation.

But under practically uniform soil conditions the pure short-grass formation is found in the "Panhandle" of Texas, where the average annual rainfall is about 21 inches, and in eastern Colorado, with an average annual rainfall of 17 inches, while in Montana a comparable type of pure short-grass vegetation is found where the average annual rainfall is only 14 inches. Similar observations could be made upon any other type of vegetation which extends throughout the region. A correlation with amount of rainfall alone is not possible; for, if we judge from the vegetation, a rainfall of 14 inches in Montana is equivalent to a rainfall of 21 inches in Texas. Lines drawn from north to south showing conditions equally favorable for plant growth, as we pass southward, cross lines of increasingly higher annual rainfall. It is clear in this case that factors other than the amount of annual rainfall must enter into the correlation,[a] since on a uniform soil differences in the amount of annual rainfall produce no changes in the type of vegetation.

To attempt a close correlation of plant associations with temperature alone is equally difficult. The short-grass and prairie-grass formations each range from the Lower Austral through the Upper Austral and into the Transitional life zone, taking these life zones as defined by Merriam.[b] It is obvious that in the region here considered water is the chief limiting factor and temperature is of comparatively minor importance in influencing plant distribution.

From the cases above mentioned we can see that neither the rainfall nor the soil type alone determines what type of vegetation will be found in any given area; for of the first two correlations discussed in which only these factors are primarily concerned, either may be cited to disprove the other. Many similar examples could be given, but these will serve to show how utterly impossible it is to

[a] See Powell, J. W., "Lands of the Arid Region," 1879, p. 51, and Johnson, W. D., "The High Plains and Their Utilization," Twenty-First Annual Report of the United States Geological Survey, pt. 4, 1901, p. 678; also Briggs, L. J., and Belz, J. O., "Dry Farming in Relation to Rainfall and Evaporation," Bulletin 188, Bureau of Plant Industry, United States Department of Agriculture, 1910, pp. 20–22.

[b] Merriam, C. Hart. Laws of Temperature Control of Geographical Distribution of Terrestrial Animals and Plants. National Geographic Magazine, vol. 6, 1895, pl. 14.

make a close correlation between a type of vegetation and any single factor of the plant environment if in so doing we neglect other factors.

In most of the investigations that have been made in this field the investigators have not fully considered the effect of variations in factors other than the one with which they sought to establish correlations. If they have failed to make their case it is largely because their generalizations from the data in hand were too broad. The vegetation is undoubtedly of value as an indicator of different soil types in regions where climatic conditions are uniform, but correlations established in one region must not be applied to other regions until they have been thoroughly tested and found to hold true.

CORRELATION WITH SOIL MOISTURE.

One of the most successful correlations yet attempted is that between plant associations and water content of the soil. This correlation, set forth in 1823 by Schouw,[a] has been accepted and modified by leading ecologists[b] and has proved one of the most useful generalizations in the study of vegetation. The great ecological divisions of the earth's surface—ocean, forest, grass land, and desert—are largely expressions of this water relation.

Correlations of vegetation with soil type are, in the great majority of cases, really correlations with soil-water content, soil texture being chiefly important to the plant through its influence upon available moisture. One of the greatest difficulties in the local application of this correlation has been the fact that the water relations of the different types of soils have been defined only in a very general way. Because of this fact very little of the water-content work that has been published is of practical value. Determinations are almost worthless unless checked carefully by some such standard as "nonavailable moisture" or "moisture equivalent" (p. 18). As has been often pointed out, the moisture relations of different soils are so variable that a mere statement of per cent of water means almost nothing. Clay, for example, is as dry as dust to the plant when it contains 18 per cent of water, while most sands are very nearly saturated with 18 per cent of water.

A slight variation in the quantity of available soil moisture would probably have less effect on the character of the vegetation than would a difference in the season of the year or in the length of time during

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[a] See Schouw, J. F., "Grundzüge einer Allgemeinen Pflanzengeographie."

[b] See Warming, Eugenius, "Plantesamfund. Grundträk af den ökologiske Plantegeografi," 1895, and "Ecology of Plants," 1909; Schimper, A. F. W., "Pflanzengeographie auf Physiologischer Grundlage," 1898; and Clements, F. E., "Research Methods in Ecology," 1905.

In the plant cover as a whole we have a record which is as stable as the most stable single species and as sensitive as the most exacting plant. Any change in the physical conditions produces an immediate effect on the growth of the year, and, to a less extent, on the perennial growth as well. Notwithstanding this, one can read from the vegetation the record of the average and not of the exceptional years. If rightly interpreted the vegetation offers a record far more valuable and far more complete than any series of meteorological observations now available. In the present work we are concerned with soil and atmospheric studies only in so far as they aid in the determination of a direct correlation between native vegetation and crop production.

The effects of mowing, grazing, fires, etc., must be taken into full account in determining correlations. The vegetation which in one place indicates a heavy soil may in another indicate a lighter soil where fires occur occasionally. Vegetation which in one case indicates a rather heavy type of soil with light rainfall may in another case indicate the same type of soil and a heavier rainfall if the land is exposed to excessive grazing. It is necessary, therefore, to determine very carefully the conditions under which particular types of vegetation have developed before attempting to correlate them with the possibilities of crop production.

METHODS.

In using the native vegetation as an indicator the first step is to make a thorough study of the plant cover in order to become familiar with the more important species and the plant associations which they form. The dominant associations as well as the less important ones should be clearly recognized and defined. The definition of the various associations is best accomplished by the use of modern ecological methods. The method found most valuable in the present work was that known as the quadrat method.[a]

Where exact records of the structure of the plant cover were desired, a quadrat of 1 yard (or 1 meter) was mapped in detail on cross-section paper (fig. 1). These maps were most useful as records of typical portions of plant associations. The areas occupied by the different plant associations were mapped by means of colored pencils on blank township maps on a scale of 1 inch to the mile. When once the plant associations were clearly distinguished, the geographical distribution of each association could be readily recorded by this method.

In addition to the work mentioned above there is the much more difficult task of determining what factors have brought about the

[a] See Clements, F. E., "Research Methods in Ecology," 1905, p. 161.

roupings of plants into these definite associations. Important as re the factors of reproduction, dissemination, and establishment, or f invasion and succession in the early stages of the associations, it is argely in the physical inequality of the plant habitat that we find the eason for the present distribution of vegetation in the region under onsideration.

In studying the factors which have contributed to the origin of a articular association we have then to take into account, first of all, he physical conditions under which the association thrives. In loing this for the region here discussed all available data have been ised. Air-temperature and rainfall records were easily obtained; an accurate record of evaporation, saturation deficit, soil moisture, and soil temperature is taken[a] at 11 different stations on the Great Plains. These more general records have been supplemented by many simultaneous comparative observations made by the writer in the different plant associations.

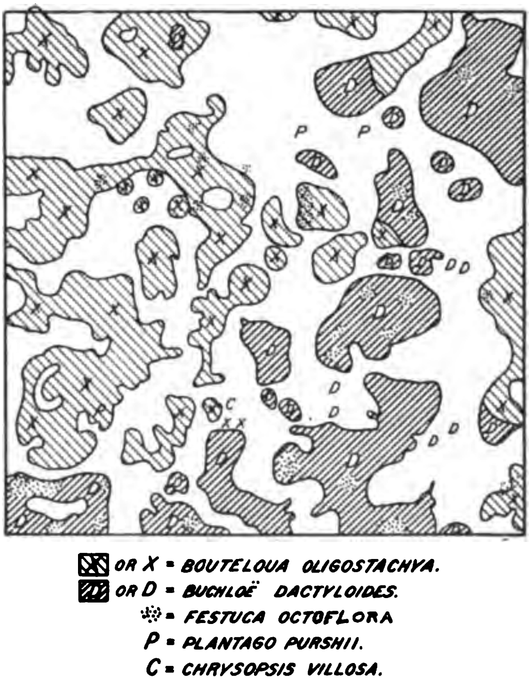

FIG. 1.—A one-meter quadrat, from the grama-buffalo-grass association (short-grass formation) at the Dry-Land Agriculture Experiment Farm, Akron, Colo.

Water is the chief "limiting factor" for plant growth in the Great Plains area. It was therefore necessary to know the amount present in the soil during the period covered by these investigations. A series of determinations made at a carefully chosen base station twice a day throughout the season gave the most valuable data that were obtained, but it was also found desirable to make occasional determinations of soil moisture at other points. These occasional determinations were made both at the same time in different plant associations and at different times in the

[a] Under the direction of Dr. L. J. Briggs, of the Physical Laboratory of the Bureau of Plant Industry.

same association, the choice of the location and time depending upon the weather and the condition of the vegetation.

The soil moisture was actually determined in percentages of water to dry weight of the soil, but in this shape the data are of little value for comparing the behavior of plants growing on soils of different texture. It was found necessary, in order to make such comparison, to reduce the data to some definite standard. The best standards for a comparison of moisture conditions in different types of soil in relation to plant growth and behavior were found to be the moisture equivalent and the nonavailable moisture.[a]

The rate of penetration is of such importance in influencing the amount of water in the soil that it was considered essential to make careful measurements of the time required for a given amount of water to enter the soil, and also of the quantity of water taken up by the soil during a rainfall of known amount.

Chemical and mechanical analyses of soils were necessary as a check upon the correlations between soil moisture and plant distribution. The analyses required were obligingly furnished by the Bureau of Soils.

Plant migrations, invasions, and successions are of great importance in considering the origin and present structure of plant associations. In order fully to understand each particular association, how it has originated and what conditions it indicates, it was necessary to go somewhat in detail into the subject of competition between different species. In this connection a study of the root systems of the different species, as well as of the effects produced on the vegetation by fires, and by mowing, grazing, and other human and animal agencies, was found to be indispensable.

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[a] The moisture equivalent is the amount of water left in the soil when saturated soil has been subjected to a force of 1,000 times gravity. (See Briggs, L. J., and McLane, J. W., "The Moisture Equivalents of Soils," Bulletin 45, Bureau of Soils, U. S. Dept. of Agriculture, 1907.)

The nonavailable moisture is the amount of water which remains in the soil after the plant has wilted as a result of insufficient moisture. (See Sachs, Julius, "Bericht über die physiologische Thätigkeit an der Versuchstation in Tharandt," Landw. Versuchs-Stationen, 1859, vol. 1, p. 235.) The nonavailable moisture, expressed in percentages, is here used to signify the maximum percentage of water in the soil which can not be utilized by the plant, or what might be called the point of nonavailable maximum. When the amount recorded is less than this maximum nonavailable it is referred to as below the nonavailable. In figures 5 to 10, inclusive, the nonavailable maximum is represented by the zero line. (For a statement of the relation of moisture equivalent to nonavailable moisture see Table XII, p. 78.)

Hygroscopic coefficient (Hilgard, E. W., Soils, 1906, p. 196) is more difficult to determine and more easily affected by fluctuations in temperature or humidity, and on this account is not as useful as the other determinations here mentioned.

In studying a succession[a] it is necessary, first of all, to have a comprehensive knowledge of the established vegetation and to supplement this by a careful study of associations occupying adjacent areas which might influence its structure. One should clearly recognize the great primary successions which have led to the establishment of the existing vegetation, since these must be taken into account in considering the indicator value of any particular association. On the Great Plains it was necessary to extend observations over a wide area, for no correct idea of succession can be obtained unless this study has been sufficiently extended to enable one to secure a view of practically the whole field of plant migration which is directly concerned in shaping the particular association under observation.

PLANT FORMATIONS AND ASSOCIATIONS IN EASTERN COLORADO.

SCOPE OF THE INVESTIGATIONS.

While this work has been carried on to some extent in all the States in the Great Plains region, the more detailed investigations have been confined to Washington and Yuma counties, in eastern Colorado. The results are not expected to apply in their smaller details except in the region lying north of the Arkansas River and south of the South Platte, in eastern Colorado. Correlations must be somewhat modified in passing beyond the limits of this area, but with slight modifications they will probably hold good in a general way for most of the Great Plains region.

The survey of the vegetation of this region was undertaken by the use of methods outlined by Clements ("Research Methods in Ecology," 1905), somewhat modified and extended to suit the special conditions under which the work was carried on.

CLASSIFICATION OF VEGETATION TYPES.

In the classification of the plant associations no attention is paid to those associations found along the creek banks or in marsh and alkali flats, for the reason that the work is intended primarily to deal only with the vegetation of that portion of the area which receives its water supply directly from precipitation.

[a] Succession is the phenomenon of replacement of one type of plant cover by another. This change in vegetation is brought about in many ways. The plants themselves, by gradually changing the conditions, are often the most important factor in bringing about the change. Successions have been classified as to their initial cause as primary (those dealing with the revegetation of newly formed land) and secondary (those brought about by the destruction or removal of the original vegetation). Secondary successions occur most commonly as the result of human agency. (See Clements, F. E., "Research Methods in Ecology," 1905, p. 239.)

The more important plant groups which constitute the vegetation of eastern Colorado and the more important species of each group are here listed in such a way as to indicate the structural and historical relationships of the groups.

Classification of vegetation types.

Formation.[a]	Association.[b]	Society.[c]	Dominant species.
Lichen			Rinodina oreina. Lecanora calcarea. Parmelia conspersa.
Short-grass			Bouteloua oligostachya. Buchloë dactyloides.
	Gutierrezia-Artemisia		Gutierrezia sarothrae. Artemisia frigida. Bouteloua oligostachya.
	Grama-buffalo grass		Bouteloua oligostachya. Buchloë dactyloides.
		Psoralea tenuiflora	Bouteloua oligostachya. Buchloë dactyloides. Psoralea tenuiflora.
		Aristida longiseta	Bouteloua oligostachya. Buchloë dactyloides. Aristida longiseta.
	Wire-grass		Bouteloua oligostachya. Aristida longiseta. Psoralea tenuiflora.
Prairie-grass			([d])
	Bunch-grass		Andropogon scoparius.
	Sand-hills mixed		Bouteloua hirsuta. Andropogon hallii. Calamovilfa longifolia. Artemisia filifolia.
	Blow-out		Redfieldia flexuosa. Muhlenbergia pungens. Psoralea lanceolata.

[a] The plant formation is the most important vegetation type, and signifies a group of plants which have the same general growth form, or appearance. While different portions may differ widely as to the species which form the plant cover, they are similar in general outward appearance and indicate more or less uniform environmental conditions. (See Warming, E., Ecology of Plants, 1909, p. 139; and Clements, F. E., Research Methods in Ecology, 1905, p. 292.)

[b] The term "plant association" is used here in place of the technical term "consocies" (Clements, Research Methods in Ecology, 1905, p. 295). The association is usually more uniform as to species than the formation and occurs only as a major division within the formation (Warming, Ecology of Plants, 1909, p. 144).

[c] A plant society is a phase or aspect of an association characterized by some one or a few predominant species.

[d] Since only the western portion of this formation is considered, the dominant species for the entire formation can not be given.

In addition to the associations listed under the short-grass formation there are two other associations which are of great importance when considering the vegetation of the Great Plains area as a whole but which occupy a very small area in eastern Colorado. They are omitted from the above classification because it is difficult to show the relationship of the important associations when these are also listed. These associations, relatively of small importance in eastern Colorado, are as follows:

Supplementary classification of vegetation types.

Formation.	Association.	Dominant species.
Short-grass		Bouteloua oligostachya. Buchloë dactyloides.
	Grama grass	Bouteloua oligostachya.
	Wheat-grass	Bouteloua oligostachya. Buchloë dactyloides. Agropyron smithii.

A detailed botanical description of the formations and associations would be out of place in the present publication, but it seems desirable to connect these associations with those described by Pound (Roscoe) and Clements (F. E.) in the "Phytogeography of Nebraska," 1900. It must be remembered that the Nebraska work was pioneer work, and that while it was most carefully and thoroughly done, a fuller knowledge of the development of the vegetation of the plains has made it undesirable to follow closely the grouping therein set forth. The present classification corresponds only in a general way with that adopted by Pound and Clements.

As understood by the writer, the short-grass and prairie-grass formations cover practically all of the area east of the mountains and west of the Mississippi Valley forest area.

The short-grass formation in the writer's conception includes the following formations recognized by Pound and Clements, which are discussed in the "Phytogeography of Nebraska," on the pages indicated: Buffalo-grass formation, 350; Stipa formation, 381; Agropyron formation, 383; peppergrass-cactus formation, 386; beard-grass formation, 361. The Agropyron formation of Pound and Clements corresponds to the writer's wheat-grass association, and their buffalo-grass and peppergrass-cactus formation corresponds to the writer's grama-buffalo-grass association. The beard-grass formation of the "Phytogeography of Nebraska" corresponds to the wire-grass association of the present publication, and is placed by the writer in the short-grass formation because of the preponderance of grasses of the short-grass type, although it is clearly an intermediate association between the two great formations.

The prairie-grass formation, as described by the writer, is also much more comprehensive than the formation of the same name as understood by Pound and Clements (p. 348). It includes the writer's bunch-grass association, which corresponds to a part of the bluestem type of the bunch-grass formation (Pound and Clements, p. 355), and the writer's sand-hills mixed association, which also corresponds to a part of the bluestem type of the bunch-grass formation (Pound and Clements, p. 355), and to the *Artemisia filifolia* formation (Pound

and Clements, p. 372). The blow-out association of the writer corresponds to the blow-out formation of Pound and Clements (p. 365), and in the present publication is included in the prairie-grass formation, because it invariably passes directly into one of the associations of that formation. The *Artemisia filifolia* formation of Pound and Clements (p. 372) is included in the sand-hills mixed association of the writer because of the fact that this species of Artemisia so generally occurs in this association. The bunch-grass association, as it occurs in eastern Colorado, is a much more nearly closed[a] association than in portions of Nebraska, and what is said in this paper relative to the conditions indicated by this type of vegetation applies only when the ground is well covered and the vegetation is of the closed type rather than of the open type so often met with on the more unstable sand hills of Nebraska.

The great prairie-grass formation includes many associations which flourish east of the Great Plains area and are not here considered. The *Artemisia tridentata* formation, one of the principal formations occurring in the mountain region west of the Great Plains area, is found in places within the latter area, but does not belong to either the prairie-grass or the short-grass formations.

GEOGRAPHICAL DISTRIBUTION OF THE FORMATIONS.

THE LICHEN FORMATION.

Plants of the lichen formation occur wherever there are rock outcrops or where the soil is covered or partially covered with rock fragments. Naturally they are most important near the mountains.

THE SHORT-GRASS FORMATION.

Occupying the greater part of the Great Plains area, the short-grass formation in the United States extends from southern Texas to northern Montana and Dakota, and from the Rocky Mountains eastward to where it meets the prairie-grass formation in central Texas, Nebraska, and the Dakotas. It is limited on the east by the increasing moisture, which enables the deeper rooted, taller, and more mesophytic prairie-grass species to kill out the short grasses by competition. On the west it is limited by the mountain ranges with their woody vegetation, and in the intermountain areas by the xerophytic conditions which are the direct result of winter rains and dry summers. This condition of almost exclusively winter rainfall is entirely unfavorable for the shallow-

[a] Reference is here made to an association or formation in which the ground is closely covered with plants. Technically a closed formation is one into which other plants can not migrate without displacing some of those already established.

oted short grasses, but is congenial to a scattered growth of deep-oted plants, such as makes up the great *Artemisia tridentata* formaon of the intermountain areas. Within the short-grass formation iere are several well-marked associations.

The Gutierrezia-Artemisia association must be regarded as an arly stage in the short-grass formation and often represents a ansition from the lichen formation. It is an important associaon near the mountains, notably in northeastern New Mexico and outheastern Colorado, but it also occupies extensive areas in other ortions of the Great Plains, especially in places where there are utcrops of only partly disintegrated rock.

The grama-grass association is best developed .in the northern reat Plains, especially in Montana and extending south along the nountain front to central Colorado.[a] It is not an important assoiation in eastern Colorado.

The grama–buffalo-grass association is the most extensive sublivision of the short-grass formation. It predominates over the whole central portion of the Great Plains area and extends far south into Texas. In the southwestern portion it is somewhat modified by the occurrence of *Muhlenbergia gracillima* Torr., and upon further investigation this portion may prove to belong to another association.

The wheat-grass association is best developed in South Dakota, west of the Missouri River, on the adobe soil derived from the Fort Pierre shale, but it also occurs in detached areas both north and south of this region.

The wire-grass association is found chiefly in that portion of the short-grass formation which is adjacent to the prairie-grass formation. In eastern Colorado, where it covers a considerable area, it usually borders the sand hills.

THE PRAIRIE–GRASS FORMATION.

Most extensively developed in the eastern part of the Great Plains, the prairie-grass formation is limited on the east by the conditions favorable to the growth of trees with which the plants of this formation can not directly compete. The burning of the prairie grasses when they are dry is very detrimental to tree growth, and since these fires are often started by lightning the migration of trees into grassland areas, even before the advent of man, must have been accomplished with great difficulty. On this account the prairie grasses were able to occupy a great deal of land in regions where the moisture

[a] Shantz, H. L. A Study of the Vegetation of the Mesa Region East of Pikes Peak: The Bouteloua Formation. Botanical Gazette, 1906, vol. 42, pp. 16–47 and 179–207.

conditions were favorable to tree growth. While limited on the east by plant competition, this formation is limited on the west by the low water content of the soil. Although the physical environment in the prairie-grass formation is favorable to the short grasses, they are shut out by direct competition with the taller and deeper rooted species. On the other hand, as we pass westward the prairie grasses are gradually shut out by insufficient water supply and the short grasses are left in possession. Within the area of the present investigations the prairie-grass formation is represented only by the bunch-grass association, the sand-hills mixed association, and the blow-out association.

The bunch-grass association embraces the type of native vegetation that, according to early reports, originally occupied eastern Kansas.[a] It extends northward in a somewhat modified form into the Dakotas and southward in a typical form far into Texas. It pushes westward on sandy land into the midst of the short-grass formation, occupying large areas in western Nebraska and Kansas, eastern Colorado, and northern Texas.

The sand-hills mixed association occupies extensive areas in sand-hill regions, and has practically the same distribution as the bunch-grass on the sandy lands of western Kansas and Nebraska, eastern Colorado, and northern Texas.

The blow-out association represents the earliest stages of the sand-hills mixed association and is highly developed only in the regions of moving sand.

ASSOCIATIONS IN EASTERN COLORADO WHICH INDICATE LAND OF AGRICULTURAL IMPORTANCE.

THE GRAMA–BUFFALO-GRASS ASSOCIATION.

General Appearance.

Representing the most typical form of the short-grass formation, the grama–buffalo-grass association presents an appearance of extreme monotony. The plant cover is uniform and velvet-like; in some places it covers practically the whole surface of the ground; but in other places it is broken up into alternating spaces of open ground and dense, mat-like cover (fig. 1). The amount of soil surface covered varies from as low as 10 per cent to as high as 90 per cent. The plant growth is usually closest where there is a mixture of buffalo grass and grama grass. Where grama grass largely predominates the vegetation is often of the open-mat type. (See p. 44.) In the pure form of this association there are practically

[a] Hall, Elihu. Notes on Some Features of the Flora of Eastern Kansas. American Journal of Science and Arts, vol. 50, 1870, pp. 34, 35.

no plants which rise above the short-grass layer. Reference to Plate I, figure 1, will give the best idea of the general appearance of this type of vegetation.

BOTANICAL COMPOSITION.[a]

In eastern Colorado the short-grass vegetation is composed almost entirely of two species, grama grass (*Bouteloua oligostachya* (Nutt.) Torr., fig. 2) and buffalo grass (*Buchloë dactyloides* (Nutt.) Engelm., fig. 3). It is not an uncommon thing to find areas (Pl. I, fig. 1) in which no other plants are apparent. Close examination, however, will show that there are other plants associated with these grasses (fig. 1).

No attempt is here made to give a complete list of the plants which may occur in this association in addition to grama grass and buffalo grass, but a few of the more important species are given in the order of their importance in the lists below.

FIG. 2.—Grama grass (*Bouteloua oligostachya*). Typical plant, *a*; empty glumes, *b*; perfect and imperfect flowers, *c*.

[a] Under this heading it seems best to give botanical names with citations of the author for convenience in referring to any standard manual for a botanical description of the plants. Author citations are thus avoided in other portions of the text except in connection with names which do not occur in the lists under this and similar headings. The following works will be found to be most useful in identifying the plants of this region: Britton, Manual of the Flora of the Northern States and Canada, 1901; Rydberg, Flora of Colorado, 1906; Robinson and Fernald, Gray's New Manual of Botany, 1908; Coulter and Nelson, New Manual of Botany of the Central Rocky Mountains, 1909.

Specimens of the species mentioned in this paper will be found on deposit in the National Herbarium, with the writer's identifications and reference to this bulletin.

The annual growth which occasionally becomes quite noticeable during June is composed largely of:

Festuca octoflora Walt.	Salsola pestifer A. Nels.
Plantago purshii R. & S.	Munroa squarrosa (Nutt.) Torr.
Draba micrantha Nutt.	Leptilon canadense (L.) Brit.
Dysodia papposa (Vent.) Hitchc.	Chenopodium leptophyllum (Moq.) Nutt.

FIG. 3.—Buffalo grass (*Buchloë dactyloides*). Pistillate plant, *a;* staminate plant, *b;* pistillate spike, *c;* staminate spikelets, *d*.

The Festuca is the most important of these annuals. It is one of the most noticeable plants during wet periods in early spring. Often the landscape appears bright green largely because of the luxuriant growth of this small annual grass. It requires a very short season and will ripen in about thirty days. At its ripening period the appearance of the landscape is brown and dead. *Plantago purshii* is probably as uniformly distributed but not usually so abundant as the Festuca.

There is great variation from year to year in the amount of growth of these native annuals. They are especially abundant and noticeable during wet years. All are diminutive, the smaller plants of each species being hardly more than an inch in height, while the larger plants seldom reach a height of more than 6 inches. They are all short-season plants and are able to ripen a few seeds even under most unfavorable conditions.

The following longer lived plants are commonly found in this short-grass cover:

Schedonnardus paniculatus (Nutt.) Trelease.
Opuntia polyacantha Haw.
Opuntia fragilis Haw.
Echinocereus viridiflorus Engelm.
Mamillaria vivipara (Nutt.) Haw.
Malvastrum coccineum (Pursh) Gray.
Grindelia squarrosa (Pursh) Dunal.
Astragalus crassicarpus Nutt.
Sitanion hystrix (Nutt.) Smith.
Ptiloria pauciflora Raf.
Gaura coccinea Pursh.
Erigeron canus Gray.
Aragallus lambertii (Pursh) Greene.
Astragalus mollissimus Torr.
Erysimum asperum DC.

Of the longer lived plants which commonly occur in this short-grass cover one of the most noticeable is the cactus (*Opuntia polyacantha*), which forms extensive societies[a] at many places in the Great Plains. In eastern Colorado cactus occurs commonly, but is seldom of importance. Evidence shows that it was once far more abundant than at present, and many of the plants now found are dying as a result of fire and the attacks of parasites.

Schedonnardus and Malvastrum are found almost everywhere, but they never become dominant on the native sod. Grindelia in some places develops so abundantly that it becomes the most noticeable feature, dominating an extensive plant society.

Most of the plants listed have a root distribution approximately the same as that of the short grasses themselves. An exception is noted in the case of the species of Astragalus, which are deeper rooted, but, on the other hand, require only a very brief growing season.

Plants which often occur here but which are more characteristic of other associations within this formation are as follows:

Artemisia frigida Willd.
Gutierrezia sarothrae (Pursh) B. & R.
Aristida longiseta Steud.
Psoralea tenuiflora Pursh.
Agropyron smithii Rydb. (A. occidentale Scribn.).
Sideranthus spinulosus (Pursh) Sweet.
Chrysopsis villosa Nutt.
Eriogonum effusum Nutt.
Liatris punctata Hook.

All, or nearly all, of the species in the above list are better developed in the wire-grass association (p. 48), and their occurrence amid short grass, especially if they are abundant, indicates conditions approaching those found where the wire-grass association occurs. Several of these species reach their highest development in the Gutierrezia-Artemisia association (p. 60). The significance of the presence of these species is discussed in connection with these other two associations.

Physical Conditions Indicated.[b]

SOURCE OF DATA.

In order to give a clear account of the conditions under which the short grasses succeed, it is necessary to present some of the physical

[a] See footnote c, p. 20.

[b] The physical conditions of land originally occupied by vegetation of this type when under cultivation are discussed on p. 70.

data obtained at Akron, Colo.,[a] during the growing season, from June 2 to September 27, 1909.

In presenting these data only such records as are indispensable to the explanation of the conditions indicated by the different associations are included. Temperature, light, evaporation, etc., are practically uniform throughout eastern Colorado. The seasonal distribution of rainfall or the monthly rainfall is of far greater importance than annual rainfall, and is given here in order to help explain the conditions found in the different associations. Rainfall is the same for the different plant associations, and although this factor is discussed under only this one association the discussion applies equally to the others.

RAINFALL.

The following is the daily rainfall record in inches for the entire growing season of 1909 as recorded by the Physical Laboratory of the Bureau of Plant Industry at the Akron Experiment Farm.[b] This record gives a very good idea of the daily distribution of rainfall and is indispensable in interpreting the soil-moisture curves (figs. 5, 6, 7, 8, 9, and 10). A comparison of the diagrams in figure 4, as well as a comparison of the actual data on which these are based as given in Tables I and II, show very clearly that the season during which the soil-moisture determinations were made was unusually wet.

TABLE I.—*Days of rainfall and the amount of daily rain at Akron, Colo., April 1 to September 30, 1909.*

Day of the month.	Rainfall in inches.					
	Apr.	May.	June.	July.	Aug.	Sept.
1			0.06			0.13
2			.01			1.12
4	0.14			0.02		.23
5	.06		.01			.04
6			1.02	.01		
7	.02	Tr.	.07	2.39	0.48	Tr.
8			.04	.32	.96	
9			1.06	.09		
10			.30			
11	.04		.26			
12		0.04				.36
13			.32			.28
14					.74	
17		.06				
18					.64	

Day of the month.	Rainfall in inches.					
	Apr.	May.	June.	July.	Aug.	Sept.
19		0.42	0.02			
20	0.14	.31	.08			
21				0.01		
22		.06				
23		.08				
24		.17	.07	.08	0.06	
25		.08				
27				.80		
28		.12				
29				.89		
30		.34				
31		.19			.89	
Total.	.40	1.87	3.32	4.61	3.77	2.16

[a] The writer's headquarters during the season of 1909, when the data here presented were largely obtained, were at the experiment farm of the Office of Dry-Land Agriculture, 5 miles east of Akron, Colo. The farm is located in an area covered by short-grass vegetation.

[b] Free access to the records in the office of the physicist of the Bureau of Plant Industry was accorded the writer. To Dr. L. J. Briggs the writer is indebted for the records of rainfall and evaporation at the Akron Experiment Farm, for moisture equivalent and hygroscopic moisture determinations of many soil samples, and for many determinations of moisture content on the cultivated plats. Although not here included, these records greatly aided in the general discussion of the conditions favorable or unfavorable for crop production on the short-grass land.

ABLE II.—*Average, maximum, and minimum monthly rainfall recorded at twelve stations in eastern Colorado previous to the year 1909.*

Month.	Average.	Maximum.	Minimum.	Month.	Average.	Maximum.	Minimum.
anuary	0.32	2.35	0	July	2.77	6.72	Trace.
ebruary	.52	1.98	0	August	2.23	6.64	Trace.
arch	1.08	4.47	Trace.	September	1.05	3.73	0
pril	2.48	11.11	Trace.	October	1.00	3.20	0
ay	2.46	9.77	Trace.	November	.46	4.40	0
ne	2.61	6.30	.72	December	.42	2.00	0

The average monthly rainfall, as shown in Table II, is based on ll of the monthly records up to and including 1908 for the following stations in eastern Colorado: Akron, Fox, Wallet, Burlington, Holyoke, Wray, Cheyenne Wells, Julesburg, Yuma, Cope, Siebert, and Leroy. The average length of record for the twelve stations is 13.4 years, and these data should give a very good general idea of the distribution and amount of monthly rainfall for this portion of the Great Plains. The least and the greatest monthly rainfall are also of interest to show the extremes.

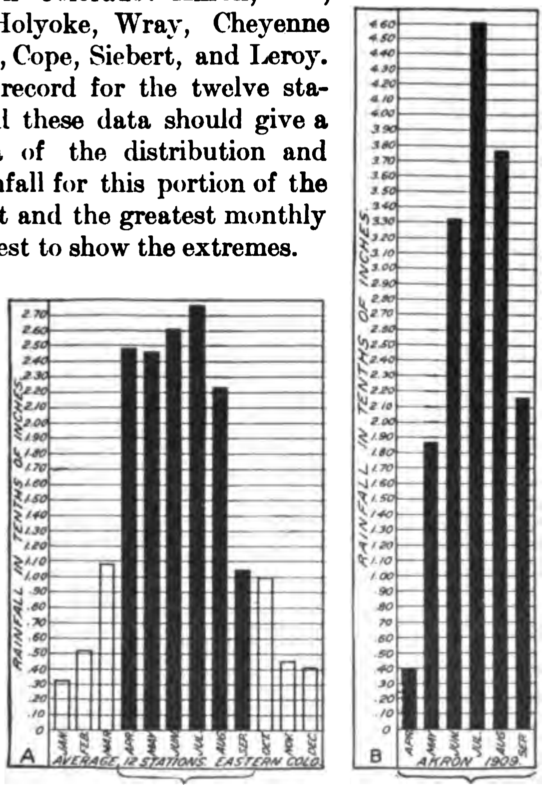

FIG. 4.—Diagrams showing: *A*, The average monthly precipitation based upon all records from twelve stations in eastern Colorado; *B*, the rainfall at Akron, Colo., season of 1909, for the months April to September, inclusive.

The annual rainfall alone gives almost no idea of the conditions favorable or unfavorable for crop production, for crop failures often occur during the years with the greatest annual rainfall. The average annual rainfall for the twelve stations is 17.40 inches. The greatest annual rainfall for this region was recorded at Cope in 1898 and was 28.48 inches, while the lowest annual rainfall, 5.70 inches, was in 1893, at Fox, a few miles distant from Cope. There is no evidence, either from the vegetation or from the oldest of the Weather Bureau records, that the rainfall is permanently increasing or decreasing in amount.[a]

[a] U. S. Weather Bureau, Precipitation in Western Kansas, Abstract of Data No. 2, 1907.

SOIL-MOISTURE CONTENT.

Soil-moisture determinations were taken on the Akron Experiment Farm twice a day from June 10 to September 10, 1909.[a] The sampling was done with a soil tube. In the morning samples were taken to a depth of 6 feet, the first 3 feet being in 6-inch samples while the second 3 feet were taken in samples of 1 foot each. In the evening samples were taken for each 6 inches to a depth of 3 feet only. Each sample for a given depth consisted of three cores. Several series of samples were taken before June 10 and one series of samples on September 27, thus extending the records from June to September 27. In collecting this series of samples care was taken to select spots where comparatively pure short-grass cover occurred. Samples were taken as near together as possible, but with precautions to insure against the effect of water penetration from the holes where previous borings were made. The samples were thoroughly dried in an oven at 100° C. and the moisture content expressed in percentages of the dry weight of the soil.

The seasonal variations in available soil moisture, as calculated from the results of the daily sampling just described, are shown in the curves in figures 5, 6, 7, 8, 9, and 10. Each curve is made up of 184 points, except that curves for the soil below 36 inches contain only 95 points. The fluctuations observed in these curves are due largely to variations in the texture of the soil. These variations occur even at the short distances apart at which the corresponding samples were taken on successive dates. This is especially true with respect to the curves representing the water content in the deeper layers of the soil. In many places where the determination showed a low moisture content the soil sample was sandy; where high the soil contained more clay. If it had been possible to check each individual determination by a moisture equivalent or nonavailable moisture determination[b] the curves would show much less variation. However, the general trend of the curve is not vitiated by these fluctuations, since it is clear that they do not represent actual gain and loss in water but are the result of extremely local variations in soil texture.

The curves are based upon determinations of actual water content corrected to represent the amount of water available to the roots of

[a] Prof. L. F. Childers, now of the Idaho Experiment Station, assisted the writer in this work as special agent of the Bureau of Plant Industry at Akron during the summer of 1909.

[b] See footnote, p. 18.

ubanka wheat, as estimated from the moisture equivalent of soil rom each depth.[a] In order to read them in terms of the actually bserved water content it is necessary to add to the percentage represented at each point on the curves for the respective depths the ercentages recorded in Table III.

ABLE III.—*Water nonavailable for Kubanka wheat in percentages of dry weight of soil, estimated from the moisture equivalent of a composite sample of all soil taken at each depth.*[a]

Depth in inches.	Per cent.	Depth in inches.	Per cent.	Depth in inches.	Per cent.
0- 6	9.6	18-24	10.5	36-48	7.1
6-12	14.5	24-30	9.2	48-60	7.0
12-18	12.8	30-36	7.9	60-72	6.3

The most interesting thing brought out by these curves is the fact hat during the period of observation the rainfall did not at any time alter the water content of the soil below the first 18 inches. In fact, the curve representing the depth 12 to 18 inches was not influenced by a rainfall of as much as 2.40 inches on July 7 (fig. 5), nor by any of the rains which occurred later in the season (figs. 5 and 6).

A rainy period during the last of May and early June, before regular soil sampling was begun, influenced considerably the soil below 18 inches, as is shown by the subsequent general decline of the curves for 18 to 24 and 24 to 30 inches (fig. 7, *A;* fig. 8, *A*), from June 10 to about July 22, after which they remain approximately constant. The curves (fig. 7, *B;* fig. 8, *B*) show that the moisture content of this soil below 3 feet was not increased at any time during the season as a result of precipitation occurring after the sampling was begun and that on this hard land, even during the period when there was much more than the normal rainfall, the soil moisture available for Kubanka wheat was limited to the surface 3 feet of the soil.

Table IV summarizes the average available and nonavailable water between certain dates for each depth of the soil, and shows clearly the periods when water was available or not available. The average for each depth for the whole period is also given.

[a] See Table XII, p. 78, and footnote. The particular lot of seed used in the pot-culture experiments by which the nonavailable moisture was determined for Kubanka wheat was that distributed by the Department of Agriculture, under Seed and Plant Introduction No. 5639.

TABLE IV.—*Periods when water was available and amount at each depth, in percentage of dry weight of soil, also general average at each depth for the whole season, June 7 to September 10, 1909.*

Depth of soil sampled (inches).	Period.	Average percentage of available water. For period.	Average percentage of available water. For whole season.
0-6	June 7 to June 24 a. m.	9.8	
	June 24 p. m. to July 6	– 1.56	
	July 7 to July 19 a. m.	7.82	
	July 19 p. m. to July 26	– 1.71	
	July 27 to August 4 a. m.	4.67	4.8[illegible]
	August 4 p. m. to August 7	– 2.51	
	August 8 to August 27 a. m.	4.23	
	August 27 p. m. to August 31	– 2.32	
	September 1 to September 10	12.81	
	September 27	1.0	
6-12	June 7 to July 22 a. m.	5.67	
	July 22 p. m. to September 3	– .40	2.[illegible]
	September 4 to September 10	4.08	
	September 27	2.8	
12-18	June 7 to July 18 a. m.	4.84	1.[illegible]
	July 18 p. m. to September 10	– 1.54	
	September 27	– 1.7	
18-24	June 7 to July 19	3.23	.[illegible]
	July 20 to September 10	– 1.43	
	September 27	– 2.0	
24-30	June 7 to July 19	1.72	.[illegible]
	July 20 to September 10	– .81	
	September 27	– 2.1	
30-36	September 27	– 1.2	.0[illegible]
36-48	do	– 1.2	– .[illegible]
48-60	do	– .3	– .0[illegible]
60-72	do	.3	.0[illegible]

As previously shown (fig. 4, p. 29), the season of 1909 was abnormally wet. Notwithstanding this fact, there were three periods when practically no water was available in any depth of the soil reached by the borings. These periods were from the evening of July 23 to the evening of July 26, inclusive; from the evening of August 4 to the evening of August 7, inclusive; and from the morning of August 28 to the evening of August 31, inclusive.

Below 6 inches there was no available water from July 22 to September 3, and below 12 inches there was none available later than July 19. Water was available in the soil at the depth of 30 to 36 inches during only a few days in June, and there is no evidence to show that water was again available in this layer after June 11. The soil below a depth of 36 inches was not influenced by the rainfall and its water content was practically constant through the season.

It is evident that except as an immediate result of the rainfall of a single day no water was available at any depth after July 22, and that even at such times the water available was found only in the

urface foot of soil. For the period July 22 to September 1 the only vailable water at any time was in the surface 6 inches. The second -inch layer was only slightly affected by several rather heavy rains, nd was brought above the nonavailable point by only two heavy ains, August 31 and September 1. It is also interesting to see that nore than three days passed before the water added by these rains ccasioned an increase in the water content of the second 6 inches.

The water content of the first 6 inches varied more than that of any ther depth. During the season the water content of this first 6-inch ayer fell below the available for several days at four different periods.

The water content of the soil from 6 to 12 inches remained below he available for a long period, July 22 to September 3, and also for he three days July 5 to 7. The water content of the soil from 12 to 18 inches did not fall below the point of availability until July 18, but after that date did not again rise to this point although many heavy rains were recorded. The same is true of the soil at depths of 18 to 24 inches and 24 to 30 inches.

A comparison of the rainfall at Akron during the season when these soil-moisture records were made with that of the average season for twelve stations in eastern Colorado (fig. 4) shows clearly that the seasonal rainfall was not only greater than the normal, but also that the period of greatest monthly rainfall began one month later and continued one month later than the normal. This being true it is probable that in a normal year the period of drought would occur much earlier in the season and that conditions would be much less favorable for the growth of plants.[a]

The point at which the water content of the soil becomes nonavailable for Kubanka wheat is comparatively low. From many observations in the field during several seasons and from experiments in the laboratory it is believed to be almost as low as that representing the nonavailable for many of the native plants of the grama-buffalo-grass association. This probability is supported by a consideration of the moisture content of the soil below 6 inches (fig. 6), which is protected from direct evaporation by the soil above. Nothing in the curves indicates that the native plants still extracted water from the deeper layers of the soil when their water content was below the available minimum for Kubanka wheat.

[a] Daily soil-moisture determinations on this type of land to a depth of 10 inches, at Yuma, Colo., during July, 1907, showed available water in the soil during only seven days in the month, and occasional determinations during August, 1907, showed the soil to be much drier even than during July.

RUN-OFF.[a]

A great quantity of rainfall runs off directly and never enters the soil. The extent of the run-off, indicated by the many large, dry, gravelly stream beds which are found in short-grass regions, has been demonstrated by actual observation during heavy rains and by the measurements here recorded. From the results of the moisture determinations—the weight of the soil, the percentage of water it contains, and the amount of precipitation being known in each case—the quantity of water which entered the soil and the quantity of run-off was easily computed. At the place where the soil samples were taken and the run-off measured the land was comparatively level. It was possible, however, for water to drain over this area from the land adjacent on the north, and consequently the run-off recorded from this particular area was lower than the average for the region.

The results of all records of run-off at the base station at Akron, Colo., from June 11 to September 10 are given in summary form in Table V.

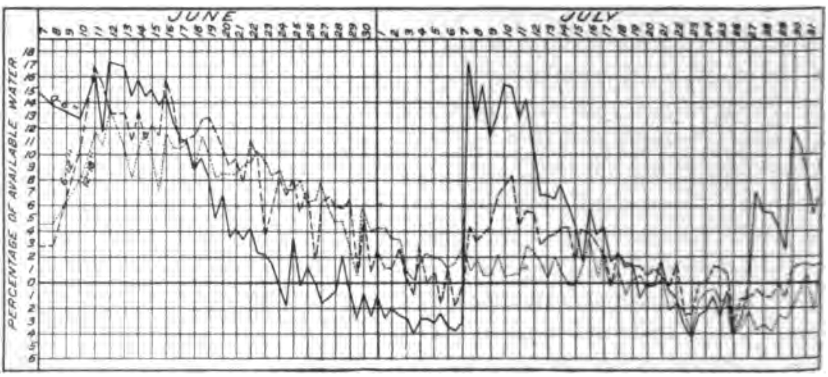

FIG. 5.—Diagram showing the daily available soil moisture, from morning and evening determinations for each 6-inch layer, 0–18 inches, in pure short-grass land, at Akron, Colo., Dry-Land Agriculture Experiment Farm, June and July, 1909.

The figures represent the average of the total quantity of water which entered the soil and which ran off, expressed in percentages of the total rainfall; they are not the results of averaging the percentages of run-off and penetration for each individual rain.

[a] Variation in the water content of the surface soil, in the rate and amount of precipitation, in the physical condition of the soil surface, and in the slope all affect the amount of run-off. The run-off from the same area will therefore vary greatly at different times. The data given in Tables VI to XI, inclusive, were obtained at points where the slope of the land and the rate and amount of precipitation were the same, the chief factors which produced the variation having been differences in the water content of the soil and the physical condition of its surface. Comparisons of the data given in any one of these tables with those in any other must be checked by reference to the continuous record made at the base station. Direct comparisons of one table with another will lead to entirely erroneous conclusions.

TABLE V.—*Percentages of the total amount of run-off and of penetration on short-grass land at the base station, Akron, Colo., June 11 to September 10, 1909.*

Rainfall.	Number of rains.	Penetration.	Run-off.
		Per cent.	*Per cent.*
Rains of 0.10 inch or more	12	85	15
Rains of 1 inch or more	2	74	26
Rains of 0.50 to 1 inch	5	85	15
Rain of 0.10 to 0.50 inch	5	125	−25

With a rainfall of less than half an inch the soil invariably received more than 100 per cent of the precipitation. This indicates that there was some drainage to this land from higher levels and that the above data on run-off represent less than would actually occur on a larger and more representative area. In order to check these results, which were obtained at a single base station, measurements were made to determine the amount of water that penetrated the soil as a result of the rain of 0.89 inch on the night of August 31, 1909, at the base sta-

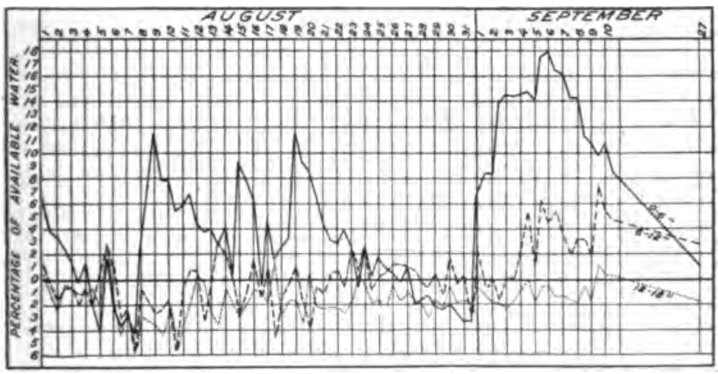

FIG. 6.—Diagram showing the daily available soil moisture, from morning and evening determinations for each 6-inch layer, 0–18 inches, in pure short-grass land, at Akron, Colo., Dry-Land Agriculture Experiment Farm, August and September, 1909.

tion and at five other points chosen to show the normal run-off for short-grass land during this rain. The results are given in Table VI.

TABLE VI.—*Run-off and water penetration on short-grass land at Akron, Colo., as a result of 0.89-inch rain August 31, 1909.*

Locality.	Penetration.	Run-off.
	Per cent.	*Per cent.*
Short-grass land at base station	90	10
Average at 5 other points chosen to show normal run-off on pure short-grass land	57	43

The data throughout the season at the base station show that 15 per cent of the rainfall did not enter the soil. Comparisons with the

measurements at five other points show that the run-off at the base station was much below the average for land covered with short grass. The average run-off during this rain for the base station and the five other points was 37 per cent, while the run-off at the base station alone was only 10 per cent. If the seasonal average at the base station was proportionately low, the run-off from the six points must have averaged about one-half of the total rainfall for the same period.

RATE OF WATER LOSS.

The rate of water loss after penetration from short-grass land, estimated from determinations of the water content of the soil and from

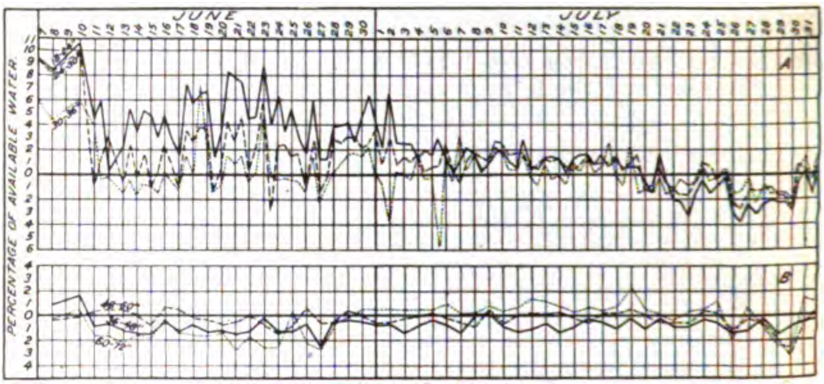

FIG. 7.—Diagrams showing the daily available soil moisture in pure short-grass land, at Akron, Colo., Dry-Land Agriculture Experiment Farm, June and July, 1909: *A*, From morning and evening determinations for each 6-inch layer, 18–36 inches; *B*, from morning determinations for each 12-inch layer, 36–72 inches.

rainfall records, with correction made for run-off during each individual rain, is given in Table VII.

TABLE VII.—*Average daily loss of water per square foot of surface from short-grass land and from free water surface for different periods during the season of growth.*

Date.	Average daily loss, in pounds per square foot of— Short-grass cover.	Water surface.[a]
June 11 to July 7	1.07	1.40
July 10 to July 25	.94	1.56
July 27 to September 10	.42	1.45
June 11 to September 10	.67	1.43

[a] The evaporation data are taken from measurements made under the direction of Dr. L. J. Briggs, of the Physical Laboratory, Bureau of Plant Industry, at the Akron Experiment Farm.

Table VII shows a marked decrease after July 27 in rate of loss of water from land covered with short grass. This is to be explained

largely by the fact that the short grasses were ripe at about that time and transpiration from the plant cover had therefore greatly diminished. These data are especially interesting in showing that transpiration by the short grasses (when in good growing condition) and evaporation from the soil itself exhaust an amount of water equivalent to the entire average rainfall of the period from April to August, inclusive, in about sixty-five days; or exhaust the rainfall of the grain-growing season, April to July, in about fifty-three days.

A comparison of the rate of loss for the two periods, June 11 to July 7, and July 27 to September 10, will throw light upon the question of how much of the water taken out of the soil was due to the transpiration of the short-grass vegetation. During the first period this vegetation was luxuriant, and as a partial consequence the average daily water loss was high, 1.07 pounds per square foot.

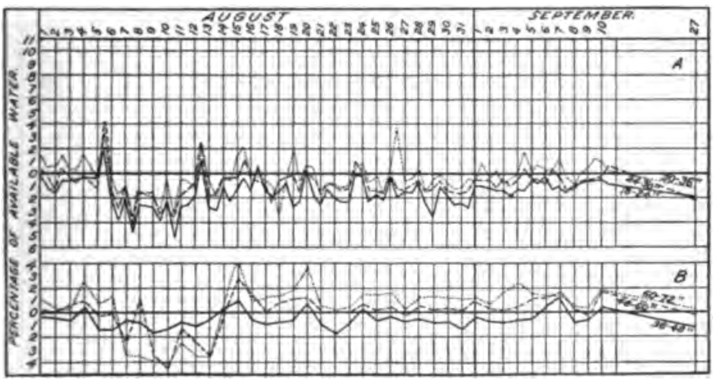

FIG. 8.—Diagrams showing the daily available soil moisture in pure short-grass land, at Akron, Colo., Dry-Land Agriculture Experiment Farm, August and September, 1909: *A*, From morning and evening determinations for each 6-inch layer, 18–36 inches; *B*, from morning determinations for each 12-inch layer, 36–72 inches.

During the last part of the season the short grasses were nearly dormant and the rate of loss was low, 0.42 pound per square foot of surface. This would indicate that considerably more than one-half of the water loss from June 11 to July 25 was due to the transpiration of the short-grass vegetation, while considerably less than half was due to direct evaporation from the soil.

The evaporation data in the right-hand column show that the difference observed in the rate of loss of water from the soil during the two periods was not due to differences in the evaporating power of the air. Reference to the curve of water content of the soil for the first 6 inches (figs. 5 and 6) also shows that the differences in rate of loss of water can not be explained on the basis of differences in the rate of evaporation from the soil due to change in its moisture

content. It seems safe to assume from these data that the transpiration from the short-grass cover during its period of active growth is responsible for considerably more than 50 per cent of the water loss.

Adaptation of Short-Grass Vegetation to Physical Conditions.

The above data show that the conditions on pure short-grass land are such as to limit the depth to which water penetrates, even after heavy rains, to a few inches of the surface soil. The soil is only rarely wet down to a foot or two. Almost the entire root system of the short grasses is limited to the surface 18 inches of soil (fig. 11). The water which actually enters the soil is rapidly lost by the transpiration of the short grasses and by direct evaporation. Deep-rooted

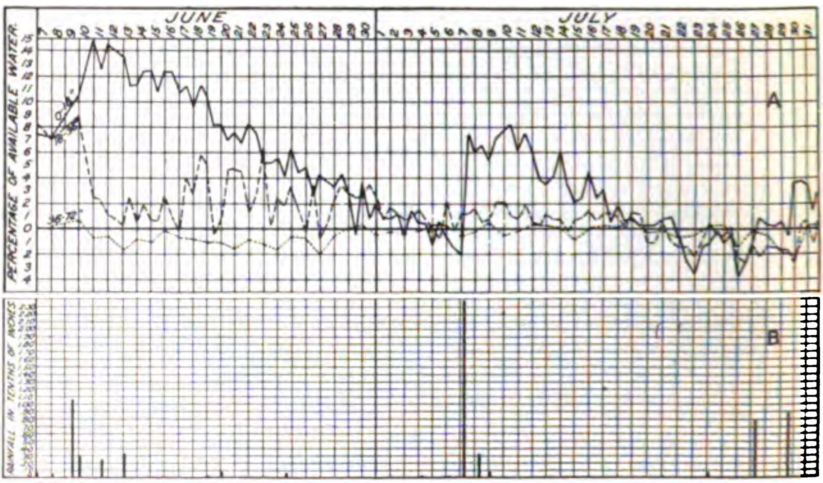

FIG. 9.—Diagrams showing, at Akron, Colo., Dry-Land Agriculture Experiment Farm: *A*, The daily available soil moisture, from morning and evening determinations for layers of soil at depths of 0-18, 18-36, and 36-72 inches, respectively, in pure short-grass land, June and July, 1909; *B*, the daily rainfall from June 7 to July 31, 1909.

plants are not found here for the reason that at greater depths the soil contains no water available for their use.

Short-grass vegetation is also an indicator of a rather short season favorable for growth. In this plant association the growing season is determined, not by the length of period of suitable temperature, but by the length of the period when the soil moisture is sufficient to maintain growth. Grama grass requires approximately sixty days for maturing and often fails to ripen its seed, largely because of insufficient water supply. Buffalo grass usually flowers and fruits early in the season, but when the early season is dry its fruiting may occur at any time during the summer when the water supply is sufficient. It usually blossoms in May, but during the season of 1908 in portions

of the Great Plains did not flower until the latter part of August. The principal adaptation of these grasses to arid conditions seems to lie in their ability to dry out, as do many lichens and mosses, and to revive quickly when water is again supplied. During periods of excessive precipitation both species of grasses grow and fruit luxuriantly. In all probability they would thrive much better under conditions of increased water supply were it not for the fact that under these conditions competition with other species becomes too severe and the short grasses are shut out. These short grasses have a very extensive surface-root system (fig. 11) and are especially adapted to conditions found in the Great Plains region on this type of land. After a slight rain, when only the first few inches of the soil becomes

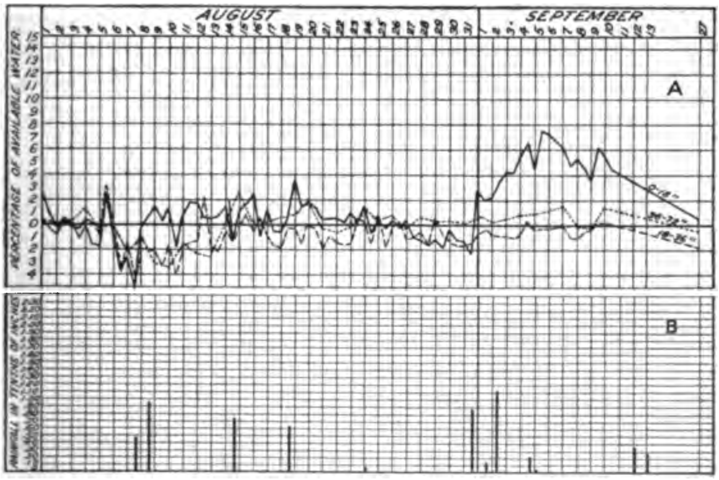

FIG. 10.—Diagrams showing, at Akron, Colo., Dry-Land Agriculture Experiment Farm; *A*, The daily available soil moisture, from morning and evening determinations for layers of soil at depths of 0-18, 18-36, and 36-72 inches, respectively, in pure short-grass land, August and September, 1909; *B*, the daily rainfall, August 1 to September 27, 1909.

wet, these plants are able to absorb water and grow. An enforced rest seems to do them no injury, and with the next shower they are able to continue their growth. Practically the same thing is true of the other species listed (p. 27) as occurring in this short-grass association.

During years of more favorable water supply an increased growth of annuals takes place. These, however, are usually found in the grass mats (fig. 1, p. 17), probably because of the fact that here the moisture conditions are more favorable for germination. The shade afforded by the grasses does not seem to be the deciding factor, since the seeds of many of the Great Plains species germinate better in light than in shade.

Conditions are not very favorable for the development of annuals on the short-grass land. A glance at the curve of available water (figs. 5 and 6) will show that seldom even during a wet year is the water content of the surface 6 inches of the soil high enough for growth during a period of more than a few days at a time. A rapid root development, as well as ability to resist desiccation, are essential to the successful growth of annuals in this environment. They also show remarkable ability to adjust the amount of growth, and hence the time of flowering and fruiting, to the supply of moisture available.

The texture of the soil indicated by short-grass vegetation in this region is a loam, the type of land known locally as "hard land," similar to that called "tight land" in Texas.

FIG. 11.—Sketch showing root systems limited to the surface soil in the grama-buffalo-grass association. Grama grass, *a*; buffalo grass, *b*.

THE EFFECT OF DISTURBING FACTORS.

BREAKING.

The effect of breaking or plowing under the short-grass cover on land that is subsequently abandoned is most marked. It results in starting a succession which requires from twenty to fifty years to complete itself by reestablishing on the area the same vegetation as that turned under. The effect of breaking varies somewhat, and the succession which ensues is determined more largely by the physical conditions than by the composition of the adjacent vegetation. The conditions for seed dispersal by wind are so favorable on the Great Plains that new land can be seeded by plants growing many miles away. The plants which enter this new area are consequently not necessarily those found immediately adjacent to the area. It often happens that a vegetation of Gutierrezia and Artemisia establishes itself upon

plowed land which is in close proximity to an area occupied by the wire-grass association, and vice versa. Many examples of this kind show clearly that the physical conditions are more important in determining what the succession shall be than the relative number of seeds of the different species which are carried into the denuded land. If the vegetation has been derived from the Gutierrezia-Artemisia association (p. 60) and occurs on land exhibiting the environmental conditions that favor that association, breaking will result first in a ruderal or weed stage composed of annuals or short-lived plants. This will be followed by a mixed vegetation in which Gutierrezia (fig. 22, p. 66) or Artemisia (fig. 23, p. 67) predominate or are associated (Pl. II, fig. 1).[a] Short grasses will gradually enter, and the later stage of this succession will show sharply alternating areas of short grass and of Artemisia or Gutierrezia. The complete reestablishment of the short-grass cover will be very slow and will probably not be fully accomplished inside of thirty to fifty years.

If, however, the composition of the short-grass vegetation is more nearly related to that of the wire-grass association (p. 48), and the conditions are therefore more favorable to this association than to the Gutierrezia-Artemisia association, breaking will result in throwing it back into the wire-grass association and the succession will then be as follows: First, an initial ruderal or weed stage[b] not differing essentially from that mentioned above. This stage is only temporary. Either of the two grasses, *Schedonnardus paniculatus* and *Sitanion hystrix*, mark the end of the ruderal stage or the beginning of the permanent stage in this succession. Wire-grass (*Aristida longiseta*, fig. 13, p. 49) will then gradually become

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[a] In the northern or northwestern portion of the Great Plains *Artemisia frigida* will probably predominate, while in the southwestern portion *Gutierrezia sarothrae* will predominate. In the central or west-central region, the portion especially considered in this paper, either or both species will become dominant in this stage.

[b] The ruderal stage varies considerably from place to place. It is usually represented by some of the following species:

Dysodia papposa (Vent.) Hitchc.	Amaranthus graecizans L.
Festuca octoflora Walt.	Amaranthus blitoides Wats.
Salsola pestifer A. Nels.	Chenopodium leptophyllum (Moq.) Nutt.
Solanum rostratum Dunal.	Lappula occidentalis (Wats.) Greene.
Malvastrum coccineum (Pursh) Gray.	Chenopodium album L.
Munroa squarrosa (Nutt.) Torr.	Solanum triflorum Nutt.
Plantago purshii R. & S.	Euphorbia glyptosperma Engelm.
Amaranthus retroflexus L.	Leptilon canadense (L.) Brit.

Of these, the tumble weeds, *Amaranthus graecizans* and *Salsola pestifer*, are often the most important species during the first year. Many of these weeds are grazed close to the ground by cattle, and doubtless close grazing greatly reduces the amount of ruderal growth. This aids in the establishment of the grasses by the removal of the taller weeds and also by reducing the rate of water loss from the soil.

established over small alternating areas and the Schedonnardus will gradually die out. Schedonnardus is a short-lived grass, and although it often dominates the early stages of this succession it offers no resistance to the establishment of the taller wire-grass, which crowds it out by overshading it. The condition of the water supply, however, is not such as to support a dense growth of Aristida, and this cover is consequently of a sparse nature and offers an excellent opportunity for the entrance of the short grasses between the scattered bunches (Pl. II, fig. 2). As these short grasses gradually become established they use up more and more of the water supply which would otherwise go to the deeper rooted wire-grass, which, as a result, gradually dies out, leaving a pure short-grass cover. The succession is very slow, requiring from twenty to forty years for completion.

It will be seen from the above discussion that the result of breaking and subsequently abandoning short-grass land is to cause the temporary establishment of a vegetation which is of a deeper rooted type and is normally characteristic of a lighter[a] or less fully disintegrated[b] soil. This is partly due to the fact that the soil has been loosened by the plowing, thus allowing water to enter more readily. Under natural conditions the soil surface in short-grass land is very hard and somewhat puddled. Breaking changes this condition and enables a greater quantity of water to enter the soil. This is especially true of land that has been plowed and subsequently not well worked down. Even in places where the soil had been left undisturbed for eight years after breaking a great difference in water content was noted in the second and third foot as compared with the same depths under unbroken sod. This condition is probably largely due to the fact that the removal of the short-grass cover by breaking decreases the loss of water that is due to absorption by the roots of these grasses. This allows the water to penetrate deeper into the soil, thus establishing a condition more favorable for deep-rooted plants.

GRAZING.

Ordinary grazing does not appreciably modify the short-grass cover. In fact, it seems that grazing somewhat favors the development of pure short-grass cover. Excessive grazing may result in one of two modifications. If the overgrazed portion of the association has recently been derived from the Gutierrezia-Artemisia association (p. 60), and presents soil conditions very similar to those normally found under that association, it will revert to that association.

[a] See wire-grass association, p. 48.

[b] See Gutierrezia-Artemisia association, p. 60.

This is the condition in southern Colorado, northeastern New Mexico, and portions of Texas where the Gutierrezia has again become established on heavily grazed land. The ranchers maintain that the range was once covered with a pure short-grass vegetation, but that grazing, and particularly sheep grazing, has caused the introduction of the Gutierrezia. The vegetation has been disturbed to such an extent that it has reverted to the earlier stage, i. e., the Gutierrezia-Artemisia association, from which in time it will pass again into the short-grass stage if protected from excessive grazing.

If, however, the area of short grass has been derived from the wire-grass association (p. 48), and presents conditions which especially favor that association, excessive grazing will cause it to revert to the wire-grass type of vegetation.

The reversion is made possible by the great reduction in the amount of short grass and the resulting reduction in loss of water from the soil. A smaller percentage of the water is absorbed in the upper layers of the soil and consequently more of it can go to the support of the deeper rooted Gutierrezia or Aristida. Neither Gutierrezia nor Aristida is eaten by animals, and these plants are consequently greatly favored by excessive grazing and the removal of the short grasses with which they are in competition for the soil water.

FIRES.

The effect of fires must be regarded as having been always operative in the Great Plains region. Fires are started by lightning during almost every thunderstorm, and the advent of man has, if anything, tended to check rather than to increase their ravages. The effect of fires on short-grass vegetation in eastern Colorado results in modifying this vegetation very markedly. Grama grass seems to suffer but little, but in places that have been repeatedly burned the buffalo grass is completely killed out. Places of this kind are marked by a pure grama-grass vegetation. Burning also removes all the dead leaves as well as the living ones, and may consequently lead to the impression that the total quantity of plant growth has been much less than is actually the case.

PARASITIC FUNGI.

In places fungus diseases play a part in modifying the short-grass cover. The two common parasites of buffalo grass, *Cercospora seminalis* Ell. and Ev. and *Tilletia buchloëana* Kellerm. and Swingle, do injury chiefly by preventing seed production. They are of minor importance except in their relation to the reseeding of areas from which the plant covering has been removed. Two fungi parasitic

on the grama grass, *Ustilago hieronymi* Schröt. and *Puccinia bartholomewii* Diet., may modify the plant cover to a considerable extent. This is especially true of the Ustilago, which in places reduces the grama to a very thin and scattered cover. Cursory observation might lead to the error of attributing this condition to unfavorable soil conditions. The disease can be recognized by the prominent smut blisters on the leaves, especially noticeable in early spring.

VARIATIONS FROM THE TYPICAL GRAMA-BUFFALO-GRASS ASSOCIATION AND WHAT THESE VARIATIONS INDICATE.

Before taking up the more marked variations from the type it will be well to consider some slight modifications in the nature of the plant cover where the vegetation still remains essentially a true short-grass type.

AN OPEN-MAT COVER.

In many places on the Great Plains the plant cover is such as can be designated an "open mat," not more than 15 to 30 per cent of the surface being actually covered with plant growth. The bare places are always irregular in shape and are usually unoccupied, even during periods when annuals develop, for the greater number of the annuals are found within the mats of grama and buffalo grass (fig. 1, p. 17). This open type of short-grass vegetation must be considered as indicating a condition less favorable for plant growth and crop production than where the ground is fully covered. As a rule it is found much more commonly in regions where the rainfall is smaller or less evenly distributed, but it may occur in almost any part of the Great Plains, especially in places where the run-off is very great. The comparative percentages of run-off from ordinary short-grass cover and from open-mat cover as a result of a rainfall of 0.89 inch on the night of August 31, 1909, at Akron, Colo., are given in Table VIII.

TABLE VIII.—*Comparative water penetration and run-off from ordinary pure short-grass cover and from open-mat cover, as a result of 0.89-inch rain, August 31, 1909, at Akron, Colo.*

Description of cover.	Penetration.	Run-off.
	Per cent.	*Per cent.*
Ordinary pure short-grass cover	62	38
Scattered mats of short grass with a little Schedonnardus	28	72

In all probability a balance is established between the amount of soil water available and the amount of plant growth produced, the growth being, therefore, an indication of the average moisture condition at that particular place. This open-mat phase sometimes

ignifies an earlier stage in the development of the true short-grass ssociation. It may be produced by fire (p. 43) or by fungous disases (p. 43), and when due to these causes does not indicate unfavorble physical conditions for the production of a cultivated crop.

A CLOSE-MAT COVER.

As the other extreme from the open mat we may have a condition vhere the plant growth is so dense that at first glance the ground ppears to be entirely covered. The vegetation affords little opporunity for the entrance of other plants without the displacement of hose already established. The close cover as compared with the rdinary short-grass vegetation signifies a soil more uniformly suplied with water and one which, when broken for cultivation, will produce better crops than that occupied by a more open cover. Exceptions should be noted when dense growths of pure buffalo grass are found in depressions where water stands after a rain. Such occurrences are not to be regarded as indicating favorable conditions for crop growth.

These differences in the amount of plant growth unaccompanied by differences in the species represented are of considerable importance as indicators of possible crop production. The appearance of other species usually accompanies more profound differences in the habitat and on this account is of greater indicator value than mere variations in the amount of growth produced. Several modifications of the latter type will now be described.

ARTEMISIA AND GUTIERREZIA ON SHORT-GRASS LAND.

In many places various perennial plants, chief among which are *Artemisia frigida* (fig. 23, p. 67) and *Gutierrezia sarothrae* (fig. 22, p. 66), establish themselves amid the short-grass cover. These plants indicate a condition intermediate between the true grama-buffalo-grass association and the association which is dominated by the perennial species mentioned. As a rule their presence indicates a less thoroughly disintegrated soil, a soil in which water penetrates somewhat deeper than where the pure short grass is found, but not so well adapted for the production of cultivated crops. Care should be exercised, however, in estimating the value of land of this type, since overgrazing or previous breaking will often introduce this type of vegetation on land which would otherwise be occupied by pure short-grass cover. Where this type of vegetation occurs naturally without the intervention of one of the above-mentioned causes, the land is to be regarded as very nearly of the type that is characterized by the Gutierrezia-Artemisia association, which will be discussed later (p. 60).

ASTRAGALUS ON SHORT-GRASS LAND.

The native Leguminosæ, especially *Astragalus crassicarpus*, *A. mollissimus*, and *Aragallus lambertii*, are rather deep rooted, but have a very short season of growth. They are, therefore, not to be regarded as indicating better physical conditions than does the pure short-grass cover, and they do not denote conditions favorable for the production of crops like alfalfa, which requires a long season.

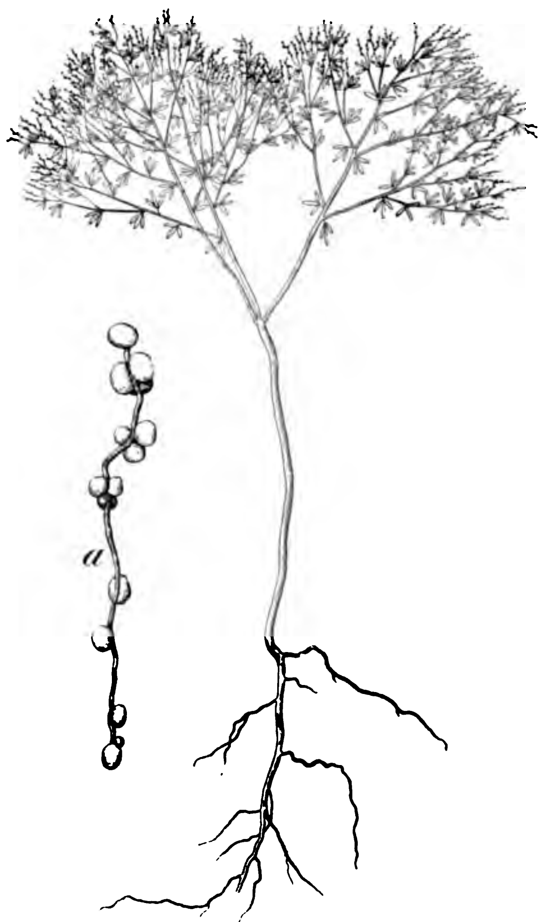


FIG. 12.—Sketch (drawn from photograph) showing a single plant of *Psoralea tenuiflora*. The root extends to a depth of 5 feet and has no surface branches. The rootlet, *a*, showing nodules, which was taken at 3 feet below the soil surface, is about natural size.

PSORALEA ON SHORT-GRASS LAND.[a]

The occurrence on short-grass land of *Psoralea tenuiflora* (fig. 12 and Pl. III, fig. 1), sometimes called "wild alfalfa," and of other deep-rooted plants which require a comparatively long season is to be regarded as an indication of a greater depth of moisture penetration in the soil. Psoralea is always a deep-rooted plant (fig. 14, p. 51), the roots extending to a depth of 4 to 6 feet. As in most of the native legumes of the region, the rootlets are well supplied with nodules for the absorption of nitrogen (fig. 12, *a*). Where this plant is distributed uniformly it indicates either a soil which is more readily penetrated by water than normal short-grass land, or else a place which receives the run-off from an extensive area and which, consequently, is penetrated by more water than that which falls upon it as rain. Accordingly, it indicates a condition more favorable for agricultural purposes than is represented by a pure

[a] *Psoralea tenuiflora* society.

›rt-grass cover. Where Psoralea plants occur only in small scat-ed communities, they indicate pockets of looser soil or depressions o which water drains from surrounding areas. Communities of oralea in many places mark animal burrows which have been andoned for some time and which afford ready means for water to netrate to deeper layers of the soil. The location of areas previously cupied by communities of Psoralea can be detected easily by the ndition of the cultivated crop during dry periods. These areas are licated by the "good spots," and if the land has not been under ltivation for a period sufficient to kill out the Psoralea it will be und still growing amid the crop in the greater number of these eas.

A careful series of comparative measurements of penetration and n-off were made following a rain of 0.89 inch at Akron, Colo., on e night of August 31, 1909, the results of which are shown in Table C. Care was taken to make the comparative borings on slopes ving as nearly as possible the same inclination.

BLE IX.—*Comparative run-off and water penetration on pure short-grass land and at places where Psoralea is present.*

Description of plant cover.	Pene-tration.	Run-off.
	Per cent.	*Per cent.*
ıre short-grass land	59	41
ose short-grass cover and Psoralea	176	− 76
ıre short-grass land	81	19
ose short-grass cover and Psoralea	140	− 40
ıre short-grass land	62	38
ose short-grass cover, wire-grass, and Psoralea	137	− 37
ıre short-grass land	90	10
soralea clump on short-grass land	274	−174
ıre short-grass land	90	10
soralea clump on short-grass land	140	− 40
ıre short-grass land	90	10
soralea and wire-grass on short-grass land	214	−114
ıre short-grass land	90	10
ne Psoralea plant on short-grass land	226	−126
Average for pure short-grass land	80	20
Average for other places	201	−101

Each comparison was made between spots where Psoralea was present as part of the vegetation and where Psoralea was absent, only a few feet away. These measurements show conclusively that where Psoralea occurs the conditions as to soil moisture are more favorable than where the short grass occurs alone.

WIRE-GRASS ON SHORT-GRASS LAND.[a]

The occurrence of scattered plants of wire-grass (fig. 13, p. 49) amid the short-grass cover (Pl. III, fig. 2), indicates somewhat the

[a] *Aristida longiseta* society.

same conditions as where Psoralea is abundant. Usually, however, wire-grass is not found in the low places where water is likely to stand after heavy rains. It is mainly an indicator of a soil into which water penetrates more readily.[a] The conditions indicated by this vegetative cover are intermediate between those of a pure short-grass vegetation and the typical wire-grass association. Wire-grass is deep rooted and has practically no surface-feeding roots (fig. 14, p. 51). Consequently, it is dependent entirely upon such moisture as occurs at a depth greater than one foot in the soil. It is therefore to be regarded in this region as one of the most reliable plants for indicating favorable agricultural conditions.

WHEAT-GRASS ON SHORT-GRASS LAND.

The wheat-grass association of the Great Plains, characterized by the predominance of western wheat-grass (*Agropyron smithii*), occurs most extensively west of the Missouri River in South Dakota, especially on the adobe soil derived from the Fort Pierre shale. In Colorado it also occupies rather extensive areas of the same kind of soil, although it is not by any means limited to this type. It seems to thrive under a great variety of conditions, penetrates farther into alkali land than do the short grasses, and is equally adapted to resist drought, chiefly by its ability to revive after desiccation. When a sod composed of wheat-grass and short grass is broken and allowed to remain without cultivation the growth of wheat-grass is greatly increased. The wheat-grass plants are not killed by this process and there is a much more abundant water supply available to them as a result of the destruction of the short grasses. In the present stage of these investigations its value as an indicator of the capabilities of crop production remains doubtful.

THE WIRE-GRASS ASSOCIATION.

GENERAL APPEARANCE.

Intermediate in character between the short-grass and the bunch-grass types of vegetation, the wire-grass association occurs most commonly on soils of intermediate character which lie between the hard lands and the sand hills. It forms a rather extensive association in certain places in eastern Colorado, being particularly abundant in Washington and Yuma counties. It is found in practically all localities where the short-grass formation and the bunch-grass association

[a] After a rain of 0.89 inch at Akron, Colo., August 31, 1909, the following comparative penetration and run-off were observed: Pure short-grass land, penetration 36 per cent; run-off 64 per cent. Wire-grass amid short-grass cover, penetration 56 per cent run-off 44 per cent. There was a decided slope where these determinations were made.

ıeet, and outside of the immediate region under consideration is robably best developed in west-central Kansas and Nebraska.

The wire-grass association is much more varied in general appearnce than the grama–buffalo-grass association. The ground is covred by a short-grass mat which is usually not so dense as that of the ypical grama–buffalo-grass association. Overtopping this mat are .umerous taller plants of many different species, among the more nportant of which are wire-grass (fig. 13) and Psoralea (fig. 12, p. 46). 'he wire-grass appears s low tufts which, beause of their light silery color, can be disinguished at once rom the so-called)unch-grass which is aller and reddish)rown in color. The wire-grass association embraces a much greater number of species than does the grama – buffalo - grass association. Even those phases of the latter which most nearly approach the wiregrass association have nothing like its variety of taller plants. Two of the most important plants, the Psoralea and the bush morningglory, are tumbleweeds, and leave no trace of their existence when the growth period is past. If the country is fenced the drift of these plants along the fences and roadways will indicate clearly the type of vegetation. The illustration (Pl. I, fig. 2) gives an idea of the general appearance of this association.

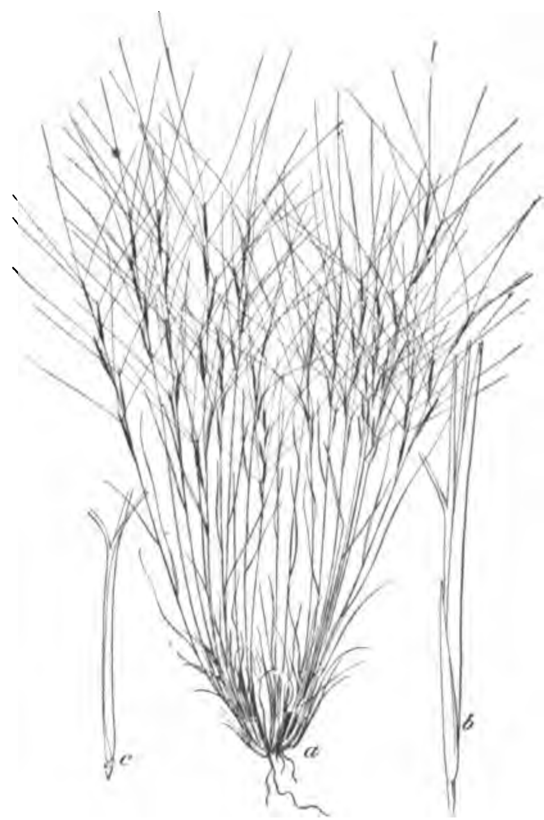


FIG. 13.—Wire-grass (*Aristida longiseta*). Plant, showing habit, *a*; spikelet, *b*; flowering glume, *c*.

BOTANICAL COMPOSITION.

The wire-grass association, being intermediate between the bunchgrass and the grama–buffalo-grass associations, is made up of species

which may be at home in either. The matlike cover is composed largely of the common grama grass (*Bouteloua oligostachya* (Nutt.) Torr., fig. 2, p. 25), although the black grama (*Bouteloua hirsuta* Lag. fig. 17, p. 59) often becomes an important factor. Buffalo grass, on the other hand, is rather rarely found, its place being taken by the black grama. Intermingled with the short-grass mat we find a great many other plants. In addition to the characteristic species, wire-grass (*Aristida longiseta* Steud., fig. 13) and *Psoralea tenuiflora* Pursh (fig. 12, p. 46), many other plants occur of which a few are here listed in order to give a better idea of the composition and general appearance of this association:

Ipomoea leptophylla Torr.
Malvastrum coccineum (Pursh) Gray.
Ratibida columnaris (Sims) D. Don.
Hymenopappus filifolius Hook.
Sideranthus spinulosus (Pursh) Sweet.
Echinocereus viridiflorus Engelm.
Liatris punctata Hook.
Thelesperma gracile (Torr.) Gray.
Erigonum effusum Nutt.
Chrysopsis villosa Nutt.
Lupinus pusillus Pursh.
Schedonnardus paniculatus (Nutt.) Trelease.
Stipa comata Trin. & Rupr.
Sporobolus cryptandrus (Torr.) Gray.
Festuca octoflora Walt.
Carex stenophylla Wahl.

The greater number of these plants are deep-rooted perennials and require a rather long season of growth. In addition to these plants, all the species recorded as occurring in the grama–buffalo-grass association (p. 25) and in the bunch-grass association (p. 54) may be found occasionally in this association.

Physical Conditions Indicated.[a]

The conditions in land occupied by the wire-grass association are such as to permit the growth of both shallow-rooted and deep-rooted plants (fig. 14). The shallow-rooted species are chiefly short grasses which obtain most of their water supply from the first foot of the soil. The texture of the soil is such, however, that water penetrates with comparative rapidity. Approximately all of the rainfall is absorbed, and since the soil is rather light in character, usually a sandy loam, this amount of water is sufficient to penetrate to a depth of several feet. As a result of these conditions this land supports also a deep-rooted type of vegetation which is characterized largely by wire-grass, Psoralea, bush morning-glory, and many other comparatively tall and deep-rooted plants. The wire-grass has practically no surface roots, the roots penetrating deep into the soil and being adapted only to conditions where the soil is moist to a considerable depth. The same is true of Psoralea, bush morning-glory, and the other deep-rooted plants.

[a] The physical conditions of land originally occupied by vegetation of this type when under cultivation are discussed on p. 75.

The presence of short grass, however, indicates a condition unfavorable to the greatest development of the taller, deep-rooted plants. If the water supply were increased the latter would undoubtedly entirely replace the short grass and the vegetation would probably pass over into the bunch-grass association.

The amount of water available below the first foot of soil determines the number of deep-rooted plants which can develop. Since in the wire-grass association this amount is not sufficient to produce a dense growth of such plants, interspaces are left which are occupied by the shallow-rooted, short grasses. The presence of the short

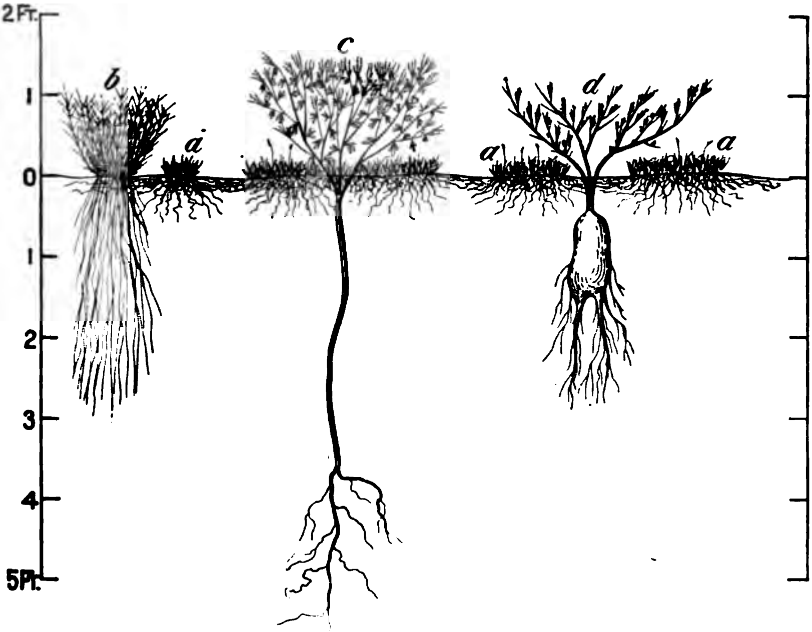


FIG. 14—Sketch showing root distribution in the wire-grass association. Shallow-rooted grama grass, *a*; alternating with deep-rooted wire-grass, *b*; Psoralea, *c*; bush morning-glory, *d*.

grasses further reduces the amount of moisture available to the deeper rooted plants but can not crowd them out entirely because of the fact that in this readily permeable soil the rain water passes below the surface layer before the short grasses can utilize all of it. A condition of unstable equilibrium therefore exists, being more favorable for the deep-rooted plants during wet years and more favorable for the short grasses during dry years.

The conditions indicated by the wire-grass association are undoubtedly the most favorable for crop production of any found in eastern Colorado, since the soil is heavy enough not to blow badly and forms a stable substratum for all types of crops. At the same time it is

pervious enough to enable a very high percentage of the rainfall to enter. The water loss from the soil surface is much less rapid than from the harder lands that are characterized by short-grass vegetation. This is due to the fact that the surface layers, being sandy, dry out very rapidly after a rain and thus soon form a protective dry mulch which checks evaporation. The greater part of the water lost by this soil is through transpiration by the plant cover.

Effect of Disturbing Factors.[a]

Breaking.—When wire-grass vegetation is plowed under and subsequently left without cultivation the result is the introduction of vegetation characteristic of a lighter type of land. The first vegetation is a weed stage which is soon followed by a stage of longer duration in which the grass *Sporobolus cryptandrus* is an important element. But this stage is by no means a pure grass stage, for many other plants also enter. Aristida next appears and at times the bunch-grass (*Andropogon scoparius*). The short grasses, chiefly gramas, are gradually introduced and the typical wire-grass association is reestablished. The succession is more rapid than that on short-grass land and the cycle is probably completed in from twenty to thirty years. One of the most interesting features is the introduction of many plants from the bunch-grass association and even of the true bunch-grass itself (*Andropogon scoparius*, fig. 15, p. 54) in the earliest stages of this succession. Breaking assists the deep-rooted plants to establish themselves by destroying the short-grass cover and allowing the water which would otherwise be absorbed by these grasses to become available to the deeper rooted plants. It is only after continued settling and puddling of the surface soil and the gradual entrance of the short grasses that the old conditions return and the short grasses are able to hold their own with deeper rooted plants, thus establishing the balanced condition which is characteristic of the wire-grass association.

Grazing.—The effect of grazing on land of this type is not very marked because none of the taller plants are eaten to any great extent by cattle and are injured only in so far as they are trampled.

[a] Fungous diseases are at times of some importance in modifying the plant cover. The more important diseases which affect this association are those on the Psoralea-bush morning-glory, wire-grass, and grama grass. Psoralea suffers severely from *Aecidium psoraleae* Pk. and is often thinned out considerably. Another disease which is less destructive is *Parodiella perisporioides* (B. & C.) Speg. The bush morning-glory is also considerably thinned by *Albugo ipomoeae-panduranae* (S.) Swingle. The diseases of wire-grass (*Sorosporium consanguineum* Ell. & Ev.) and grama grass (*Puccinia bartholomewii* Diet.) are much less destructive but may have a slight effect in modifying the plant cover.

Excessive grazing often damages the short-grass cover, thus reducing the loss of water from the upper layers of the soil and enabling more of the deep-rooted plants to enter.

Fires.—Occurring, as they usually do, during the latter part of the summer, fires do not greatly injure old plants of Psoralea and the bush morning-glory, but the seeds are destroyed and propagation is thus checked. The wire-grass, however, is badly burned. Where fires are very frequent their tendency is to convert this type of vegetation into a pure short-grass cover.

Variations from the Type of the Wire-Grass Association.

Being intermediate between the pure bunch-grass and the pure short-grass types, vegetation of the wire-grass association is found varying now in the direction of the one and now in the direction of the other. When it approaches a pure short-grass cover one or the other of the following conditions will be found to exist: (1) Either the land has become so impervious as to be in almost the same condition as the short-grass land, so that but few of the deep-rooted plants can obtain sufficient water for their requirements, or else (2) fires have completely destroyed the taller, deeper rooted plants. The evidence of fires is so unmistakable, however, that one can not easily be misled as regards this factor, the effect of which is, moreover, temporary. In an area of this type in which the deeper rooted plants have died out the old roots found in the deeper soil layers are a positive proof that the land was once occupied by the wire-grass association. Wherever the vegetation approaches a pure short-grass type owing to the impervious nature of the soil the vegetation and physical environment may be identical with that already described in the grama–buffalo-grass association under the headings "Wire-grass on short-grass land" (p. 47) and "Psoralea on short-grass land" (p. 46).

Wherever characteristic plants of the bunch-grass or of the sand-hills mixed association, such as sand sage (*Artemisia filifolia*, fig. 20, p. 64) and bunch-grass (*Andropogon scoparius*, fig. 15, p. 54), occur in the wire-grass association the indication is that the land is lighter in texture and is very similar to that characterized by those associations.

Sometimes the plant cover is very sparse, leaving a considerable percentage of the surface of the ground bare, although many different species of plants are present. This aspect of the wire-grass association is to be regarded as indicating conditions less favorable for agricultural purposes than where the vegetative cover is close and more or less uniform.

THE BUNCH-GRASS ASSOCIATION.

General Appearance.

The most extensive association on the sand hills of eastern Colorado is designated by the name of bunch-grass, which aptly describes its general appearance. As usually found in eastern Colorado, the clumps of bunch-grass are somewhat scattered, the spaces between being occupied by other plants. The general appearance of the vegetation is well shown in the accompanying illustration (Pl. IV, fig. 1). The considerable difference in the appearance of this association in different places is due largely to variation in the amount of bunch-grass present, but it can be recognized at any time of the year by the reddish-brown color of this grass. The vegetation appears much darker in color when looking against the wind than when looking in the direction the wind is blowing. In places where sand sage grows with the bunch-grass there may be a considerable variation of color.

Fig. 15.—Bunch-grass (*Andropogon scoparius*), showing habit of growth, *a;* single plant, *b;* and details of spikelet, *c, d, e, f.*

The association in eastern Colorado is by no means as open as is commonly the case in Nebraska. The soil surface is occasionally well covered by an almost pure, close stand of bunch-grass, but more often by this grass mixed with other tall grasses and with short grasses occupying the interspaces. The soil is held so firmly that there is practically no blowing in land occupied by this association.

Botanical Composition.

The botanical composition of the bunch-grass association is somewhat varied. The plant which chiefly characterizes it is the bunch-grass (*Andropogon scoparius* Michx., fig. 15), but this grass is

accompanied by a great many other species, of which the following are some of the most important:

Bouteloua hirsuta Lag.	Panicum virgatum L.
Andropogon hallii Hack.	Psoralea tenuiflora Pursh.
Calamovilfa longifolia (Hook.) Hack.	Bouteloua oligostachya (Nutt.) Torr.
Aristida longiseta Steud.	Artemisia filifolia Torr.

The bunch-grass often forms a dense growth, leaving room for few other plants. But usually the bunches are scattered (Pl. IV, fig. 1), and the interspaces are occupied by the other species above listed. As the bunch-grass becomes less dominant, conditions approach more and more nearly those found in the sand-hills mixed association (p. 58). In addition to the above all the species enumerated under the wire-grass association (p. 50) and the sand-hills mixed association may occur. To the description of the latter association especially, the reader is referred for a more complete list (p. 58) of plants that occur in the bunch-grass association.

PHYSICAL CONDITIONS INDICATED.

Where bunch-grass occurs we find a soil which contains moisture to a considerable depth. The bunch-grass itself is a deep-rooted plant, poorly adapted to absorb water from the surface soil. It is, accordingly, most commonly found on land where the bulk of the water supply lies below the first foot of soil. The greater number of the other plants found in this association have a similar root habit, but it also embraces many plants which utilize the water from the surface layers (fig. 16). Among the most important of these are the grama grasses, which here find a footing only in places not already occupied by the bunch-grass or other taller plants. All rainfall received by this type of land enters the soil and there is no run-off. The bunch-grass association in eastern Colorado occurs on a sandy soil[a] from which evaporation is relatively slow, owing to the rapid establishment of a surface mulch of dry soil after a rain. Where the water supply is sufficient an almost pure, dense cover of bunch-grass

[a] With few exceptions the bunch-grass is limited in eastern Colorado to the sand hills. The exceptions are interesting. On banks where the soil is slowly falling down and where the water accordingly penetrates to considerable depths bunch-grass dominates even when the soil is a heavy loam. In the region of Bellefourche, S. Dak., bunch-grass was found on soil derived from the Fort Pierre shale, in places where the moisture conditions were especially favorable. Occasional clumps are found in heavy land in low places in eastern Colorado, where water stands for a short time after a rain. This species occurs quite commonly on clay or silt loam ridges and "breaks." In such places the soil is loose and is wearing away rapidly, the vegetation is scattered, and the conditions for water penetration are unusually favorable. It also occurs quite commonly on the gravelly soils near the mountains. Farther east, where the moisture conditions are more favorable, it grows on a loam soil (pp. 12 and 24).

develops, but where the supply is less abundant the bunches are more scattered and there is a greater growth of short grass in the spaces between. The soil characterized by this association is not especially rich in plant food, but affords a better water supply than any other in the region.

EFFECT OF DISTURBING FACTORS.[a]

Breaking.—In eastern Colorado bunch-grass grows on a sandy soil. When such land is broken by plowing considerable blowing is likely

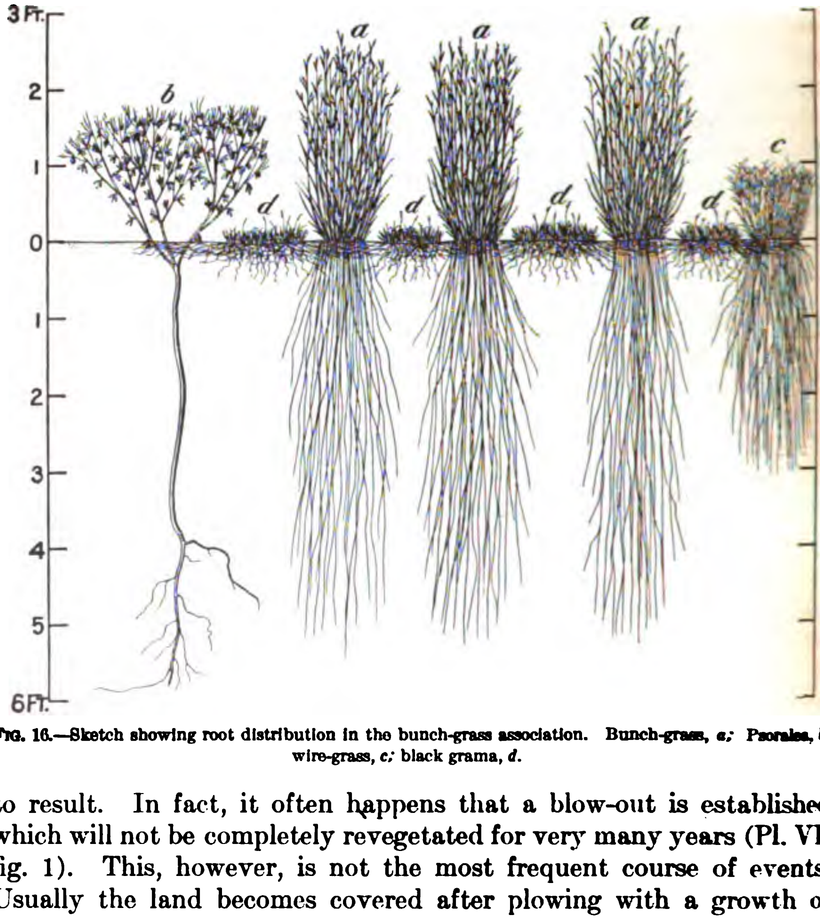


FIG. 16.—Sketch showing root distribution in the bunch-grass association. Bunch-grass, *a*; Psoralea, *b*; wire-grass, *c*; black grama, *d*.

to result. In fact, it often happens that a blow-out is established which will not be completely revegetated for very many years (Pl. VI, fig. 1). This, however, is not the most frequent course of events. Usually the land becomes covered after plowing with a growth of annual tumbleweeds, various Compositæ, amaranths, and the grass

[a] Fungous diseases have little modifying effect on this association. *Puccinia andropogonis* S. occurs on *Andropogon hallii* and rarely on *A. scoparius*, but seems to do little damage. Psoralea, wire-grass, and bush morning-glory are sometimes badly parasitized. (See footnote, p. 52.)

Sporobolus cryptandrus. Plants from the sand-hills mixed association rapidly enter and the bunch-grass soon reestablishes itself. In general, we may state that the vegetation which follows breaking land of this character, when it is left without cultivation, corresponds to an historically earlier stage in the development of this association. If a blow-out occurs, the complete reestablishment of the bunch-grass may possibly require more than a century. If the more usual course is followed, the vegetation will in all probability return to the bunch-grass type in less than twenty years.

Grazing and fires.—Grazing alone does not materially modify this association when once well established. This is due to the fact that cattle do not eat the old bunch-grass. Fire, however, is a very important factor. The great mass of dry matter produced offers favorable conditions for the spreading of fires, which are often started by lightning. Burning injures the bunch-grass to such an extent that it does not fully recover for several years. The new growth is eaten by cattle, and as a result conditions are brought about which are favorable for the entrance of the short grasses. Under conditions of frequent fires and excessive grazing the short grasses become established on land which otherwise would be occupied by bunch-grass. This is a common condition inside the fire breaks along the railroads, in which places fires are frequent. Here bunch-grass is entirely replaced by short grasses, although the land just outside the breaks, where fires are much less frequent, may be completely dominated by bunch-grass.

Variations from the Type of the Bunch-Grass Association.

Wherever the composition of the vegetation approaches very closely that of the wire-grass association (p. 48), it indicates a somewhat heavier type of soil, one which is by no means so likely to blow and yet retains its ability to take up water rapidly and to support the growth of deep-rooted plants. This land is, consequently, much more desirable for agricultural purposes than that of the pure bunch-grass type.

Wherever the growth of bunch-grass is unusually pure and dense, forming a close cover, it indicates a condition of favorable water supply, combined with rather high fertility, and is probably the most favorable type of bunch-grass land for general purposes of agriculture next to the variation toward the wire-grass association. The presence of the sand sage (*Artemisia filifolia*, fig. 20) and of the taller grasses (figs. 18 and 19) is very often associated with the occurrence of a more sandy soil and of conditions approaching those indicated by the sand-hills mixed association, which is discussed in the following section.

THE SAND-HILLS MIXED ASSOCIATION.

GENERAL APPEARANCE.

The great amount of variation found in the sand-hills mixed association (Pl. V, fig. 1) makes its general appearance rather difficult to describe. In general, it may be said to be dominated by taller growing grasses which often form large clumps several feet in diameter and which do not have the bunch-grass habit. Alternating with these are areas which are occupied by the grama grasses, *Bouteloua hirsuta* (fig. 17) being the most important, and by a great variety of taller plants other than grasses. The most characteristic feature of this vegetation is the presence of large and sharply alternating communities of the coarse-stemmed grasses, *Calamovilfa longifolia* (fig. 18) and *Andropogon hallii* (fig. 19), locally known, respectively, as "sand-grass" and "big bluestem."

BOTANICAL COMPOSITION.

The sand-hills mixed association shows great variation in botanical composition, as well as in general appearance. The following are the most important species:

Bouteloua hirsuta Lag.
Andropogon hallii Hack.
Calamovilfa longifolia (Hook.) Hack.
Artemisia filifolia Torr.
Aristida longiseta Steud.
Bouteloua oligostachya (Nutt.) Torr.
Psoralea tenuiflora Pursh.

Next to Calamovilfa and *Andropogon hallii*, sand sage (*Artemisia filifolia*, fig. 20) is the most noticeable plant. Bunch-grass (*Andropogon scoparius*) often occurs in this association, but whenever it becomes abundant the vegetation passes over to the bunch-grass association, which represents a much more stable type of vegetation.

The more open the vegetation the greater the number of species which are found. Almost everywhere there are species of secondary importance in great variety. The following list includes some of the more numerous of these plants:

Panicum virgatum L.
Ipomoea leptophylla Torr.
Yucca glauca Nutt.
Artemisia canadensis Michx.
Andropogon scoparius Michx.
Thelesperma gracile (Torr.) Gray.
Sorghastrum nutans (L.) Nash.
Chrysopsis villosa Nutt.
Bouteloua curtipendula (Michx.) Torr.
Liatris punctata Hook.
Cyperus bushii Brit.
Sideranthus spinulosus (Pursh) Sweet.
Ratibida columnaris (Sims) D. Don.
Artemisia gnaphalodes Torr. & Gray.
Petalostemum purpureum (Vent.) Rydb.
Eriogonum annuum Nutt.
Eriogonum effusum Nutt.
Sporobolus cryptandrus (Torr.) Gray.
Amorpha canescens Pursh.
Meriolix serrulata (Nutt.) Walp.
Stipa comata Trin. & Rupr.
Ambrosia psilostachya DC.
Hymenopappus filifolius Hook.
Evolvulus argenteus Pursh.
Helianthus petiolaris Nutt.
Tradescantia occidentalis Brit.
Andropogon furcatus Muhl.

PHYSICAL CONDITIONS INDICATED.

The soil on which the sand-hills mixed association occurs is usually a purer sand than that characterized by the bunch-grass association. It is a soil into which all of the rainfall penetrates, and in its water relations it is much the same as bunch-grass land. The conditions are, therefore, favorable for deep-rooted plants (fig. 21, p. 65). The danger of blowing is even greater here than on bunch-grass land.

EFFECT OF DISTURBING FACTORS.

Breaking or plowing occasionally results in establishing blow-out conditions. When blow-outs do not develop, following breaking, and the land is left uncultivated the vegetation returns rapidly to the sand-hills mixed type. In the early stages of revegetation typical blow-out grasses (p. 60) quite commonly appear.

Fire and grazing are important factors in changing this type of vegetation. Grazing alone can alter this association much more than it can the bunch-grass vegetation, from the fact that all the important grasses are eaten by stock. One of the most marked changes thus produced is that the taller grasses are eaten down close to the ground, permitting the short grasses *Bouteloua hirsuta* (fig. 17) and *B. oligostachya* (fig. 2, p. 25) to develop. Grazing is especially favorable to the sand sage (*Artemisia filifolia*, fig. 20), which is not eaten by

FIG. 17.—Black grama (*Bouteloua hirsuta*). Plant, showing habit, *a;* flowering spikes, *b;* empty glumes, *c;* perfect and imperfect flowers, *d;* flowering glume, *e*.

cattle, and upon the removal of the tall grasses and the consequent increase of moisture available in the deeper layers of the soil grows into unusually large plants. In this condition the appearance of the association is entirely altered (Pl. V, fig. 2).

VARIATIONS FROM THE TYPE OF THE SAND-HILLS MIXED ASSOCIATION.

This type varies on the one hand into the bunch-grass association and on the other into the blow-out association. (See below.) Wherever the natural vegetation is thin there is especial danger of blowouts when the land is plowed, and in such places the plant cover should never be disturbed. Wherever the vegetation is dense this land offers fairly good conditions for crop production. The presence of a luxuriant growth of sand sage (Pl. V, fig. 2) with short grasses forming a close mat between the bushes also indicates conditions which are relatively favorable for crop production.

ASSOCIATIONS IN EASTERN COLORADO INDICATING NONAGRICULTURAL LAND.

THE BLOW-OUT ASSOCIATION.

Some of the most important plants that colonize blow-outs[a] (Pl. VI, fig. 1) are:

Redfieldia flexuosa (Thurb.) Vasey.
Psoralea lanceolata Pursh.
Muhlenbergia pungens Thurb.
Petalostemum villosum Nutt.

Any one of these sand-binding plants may form an almost pure cover or they may all occur in the same blow-out. These plants are usually followed by *Calamovilfa longifolia* (Hook.) Hack. (fig. 18), *Andropogon hallii* Hack. (fig. 19, p. 63), and many other species from the sand-hills mixed association.

The soil on which this association occurs is a pure, coarse sand. Below the dry surface mulch of 1 or 2 inches the soil is usually well supplied with moisture, the conditions for the conservation of a limited moisture supply being even more favorable than on summer-tilled land of a heavier type. When once a plant is established, conditions are favorable for growth. All of the plants here mentioned spread rapidly by rootstocks and runners and have very extensive root systems.

THE GUTIERREZIA-ARTEMISIA ASSOCIATION.

The vegetation of the Gutierrezia-Artemisia association is of an open, scattered type, leaving much of the soil surface bare. It is

[a] A typical blow-out is a large, crater-like area, often several hundred feet across, usually located in the top or side of a sand hill. The term is here used for all areas where sand is not held by vegetation and is consequently moving rapidly as a result of wind action.

usually found where the surface of the ground consists of partly disintegrated rock (Pl. VI, fig. 2), and varies considerably in different portions of the Great Plains region. In the South it is characterized chiefly by *Gutierrezia sarothrae* (Pursh) B. & R. (fig. 22),[a] while farther north *Artemisia frigida* Willd. (fig. 23) becomes predominant. Except in the very earliest stages of the development of the association, *Bouteloua oligostachya* (fig. 2, p. 25) is always one of the most important elements. In the central regions the Artemisia and the Gutierrezia meet on almost equal terms. This vegetation indicates areas where water penetrates somewhat better than it does on pure short-grass land, but where, owing to the fact that the rock is not fully disintegrated into soil, the establishment of vegetation is taking place rather slowly. Such land is, of course, without agricultural value. This association includes most of the stages in succession from the first plants which appear after the disintegration of the rock commences to the final establishment of the pure short-grass cover. In its most

FIG. 18.—Sand-grass (*Calamovilfa longifolia*). Clump, showing habit, *a*; single plant, *b*; spikelet, *c*; spikelet with empty glumes removed, *d*.

[a] An attempt to recognize in the field the many species that have been described in this genus leads to the conclusion that in some cases individual plants of different ages have been described as different species, and that some of these so-called species are produced merely by the operation of drought or of wet weather. On this account it seems best to follow Coulter and Nelson (New Manual of Rocky Mountain Botany, 1909, p. 489), who state concerning the forms most commonly found on the Great Plains that "It were better perhaps to consider them forms of this (*Gutierrezia sarothrae* (Pursh) B. & R.), as did Doctor Gray."

typical aspect it is characterized by the dominance of the two species for which it is named. A great many other plants are found in this association, among which are the following:

Actinella simplex A. Nels.
Eriogonum effusum Nutt.
Hymenoppapus filifolius Hook.
Eriogonum alatum Torr.
Paronychia jamesii T. & G.
Meriolix serrulata (Nutt.) Walp.
Psoralea tenuiflora Pursh.
Sideranthus spinulosus (Pursh) Sweet.
Chrysopsis villosa Nutt.
Eriogonum jamesii Benth.
Bouteloua curtipendula (Michx.) Torr.
Artemisia canadensis Michx.
Koeleria cristata (L.) Pers.
Lesquerella argentea (Pursh) MacM.
Astragalus sericoleucus Gray.
Grindelia squarrosa (Pursh) Dunal.
Oreocarya thyrsiflora Greene.
Actinella fastigiata (Greene) A. Nels.
Lithospermum angustifolium Michx.
Artemisia tridentata Nutt.
Malvastrum coccineum (Pursh) Gray.
Plantago purshii R. & S.
Opuntia polyacantha Haw.
Mentzelia nuda (Pursh) T. & G.
Petalostemum purpureum (Vent.) Rydb.
Yucca glauca Nutt.

THE LICHEN FORMATION.

On the Great Plains plants of the lichen formation occur only on rock outcrops and rock fragments. Their distribution is, therefore, limited. In its later stages this formation often passes into the Gutierrezia-Artemisia association and frequently persists even after the establishment of the short grasses. While this formation varies considerably in the species present in different portions of the Great Plains, in its appearance, at least, it is practically uniform. Important species in this lichen covering are:

Rinodina oreina (Ach.) Mass.
Lecanora calcarea (L.) Nyl.
Parmelia conspersa (Ehrh.) Ach.
Lecanora subfusca allophana Ach.

RELATIONSHIP OF THE DIFFERENT ASSOCIATIONS.

NATURAL SUCCESSIONS.[a]

All the associations thus far described are stages in one or the other of two great successions of vegetation. One of these begins with the appearance of lichens on the rock outcrops and ends with the full establishment of a pure short-grass cover. The other, beginning with bare sand on which plants of the blow-out association first appear, leads to the establishment of the sand-hills mixed association or of the bunch-grass association, and from either of these may pass on through the wire-grass association to a pure short-grass cover.

In the first succession the lichens become established on disintegrating rocks. As soon as the rock is broken down into finer particles

[a] See footnote, p. 19, for a definition of the term "succession."

ıd soil has been formed, plants of the Gutierrezia-Artemisia associa-on (p. 60 and Pl. VI, fig. 2) begin to establish themselves, and gradu-ly the land is occupied by this association. The presence of many ›ck fragments on the surface of the soil brings about a condition ıvorable to the downward percolation of water and unfavorable to s loss by evaporation. The greater number of the characteristic lants of this association are without surface-feeding roots, yet the onditions are favorable or the growth of the hort grasses, and grama rass gradually becomes stablished. This shal-ow-rooted grass takes ıp much of the water in he surface layers of the soil, and consequently liminishes the supply which can penetrate to a depth where it becomes available to the deeper rooted plants of the Gutierrezia-Artemisia association. In the course of time the rock fragments become thoroughly disintegrated, forming a true soil, and the short grasses become dominant; the deeper rooted plants are slowly killed out and the pure short-grass vegetation is established.

FIG. 19.—Big bluestem (*Andropogon hallii*). Clump, showing habit of growth, *a*; single plant, *b*; details of spikelet, *c*, *d*, *e*, *f*.

The succession which begins with the blow-out is much more complex. The moving soil is first held by plants which constitute the blow-out association (p. 60). This gives way to the sand-hills mixed association (p. 58 and Pl. V, fig. 1) without the intervention of any factors other than the appearance of the plants themselves and the resulting increased stability of the soil. The vegetation may remain

in this condition for a long period or it may pass over into one of the modifications of the sand-hills mixed association (p. 60 and Pl. V, fig. 2), or it may gradually give place to the bunch-grass association (p. 54 and Pl. IV, fig. 1).

It is probable that without the intervention of fires or of grazing the succession would usually end at this point. But the intervention of these factors is likely to produce still further changes. The effect of frequent fires may in time change the vegetation from bunch-grass to short grass, or this result may be accomplished through the influence of grazing. The transition often takes place through the intermediate wire-grass association (p. 48 and Pl. I, fig. 2).

In a general way we may say that from the lichen formation on undisintegrated rock the vegetation passes gradually through a number of well-marked stages to the short-grass cover, and that from the first vegetation on bare sand soil (for example, in blow-outs) it passes through an even greater number of stages to the bunch-grass cover. By the aid of fires and grazing this bunch-grass cover in time often passes over gradually to the pure short-grass type.

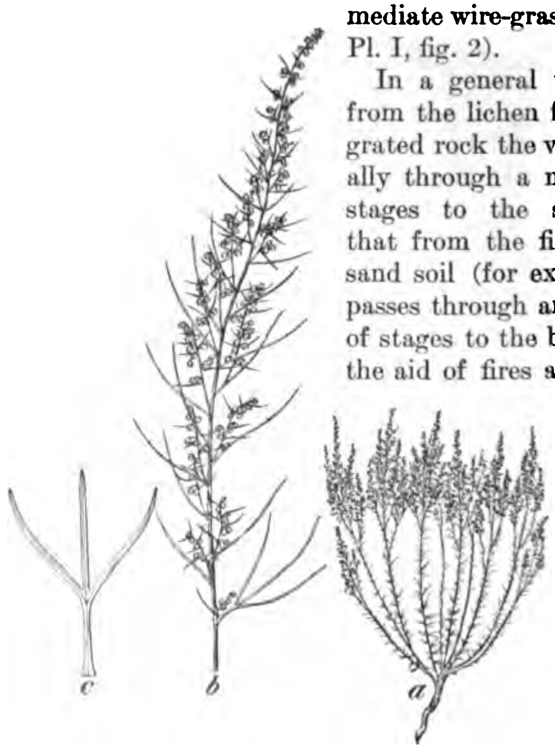
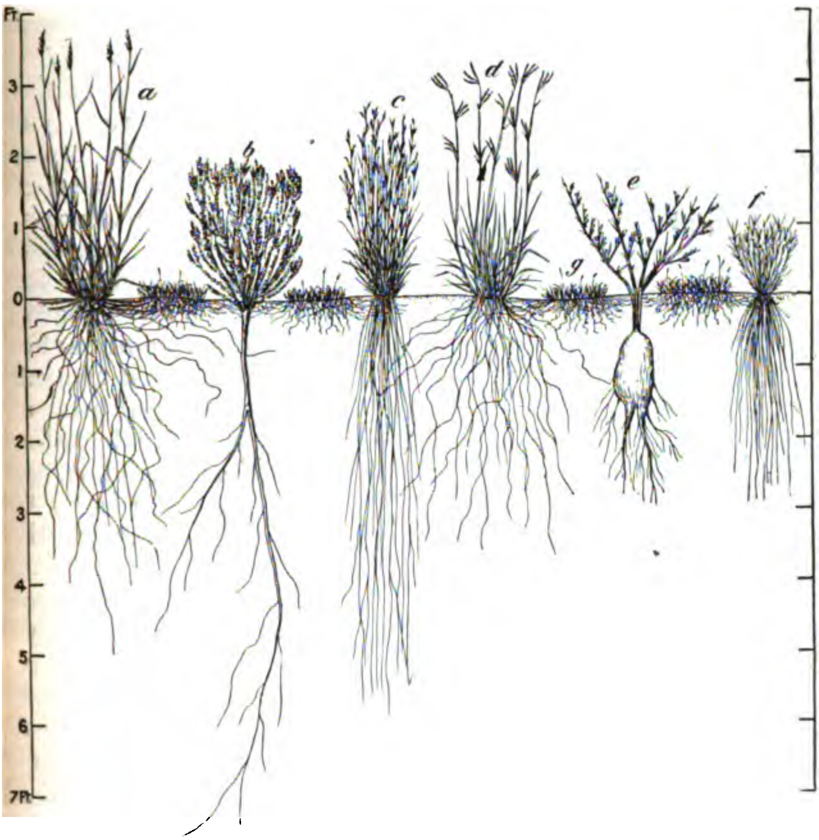


FIG. 20.—Sand-sage (*Artemisia filifolia*). Single plant, *a*; flowering branch, *b*; leaf, *c*.

Still another succession should be mentioned. Where the rocks which disintegrate are sandstone the vegetation which establishes itself after the lichen formation is not the Gutierrezia-Artemisia association, but a wire-grass or a bunch-grass vegetation. If the soil formed is exceedingly sandy, the bunch-grass vegetation may become permanently established. If, however, the soil is less sandy, wire-grass vegetation will first become established, and this will be followed gradually by pure short-grass cover.

We see, then, that short-grass vegetation represents the final stage of three different successions: First, that beginning with the lichen

rmation and passing through the Gutierrezia-Artemisia association; cond, that beginning with the lichen formation and passing through ie bunch-grass and the wire-grass associations; third, that beginning with the blow-out and passing through the sand-hills mixed asso-



'ig. 21.—Sketch showing root distribution in the sand-hills mixed association. Sand-grass, *a*; sand sage, *b*; bunch-grass, *c*; big bluestem, *d*; bush morning-glory, *e*; wire-grass, *f*; black grama, *g*.

:iation, and, with the aid of fires or of grazing, through the bunch-grass and the wire-grass associations.

SUCCESSIONS DUE TO THE INTERVENTION OF MAN.[a]

The successions due to the intervention of man are of importance in this connection from two points of view. In the first place they show to what extent damage is done to the native pasture or range

[a] See footnote, p. 19.

by breaking.[a] In the second place they throw much light upon the way in which the natural successions must have taken place, and hence their study has contributed greatly to a more complete understanding of the present structure of the different associations and what they indicate as to environmental conditions.

Wherever short-grass land is broken (p. 40) and then abandoned it is first covered by a growth of weeds, after which the type of vegetation that immediately preceded the short grass in this particular place regains possession. If, for example, we break short-grass land which has been derived from the Gutierrezia-Artemisia association and consequently offers conditions favorable to that association the land will become occupied by the latter association (Pl. II, fig. 1). The Gutierrezia-Artemisia vegetation will in turn gradually give way to the short grasses, which will be fully reestablished within a period of thirty to fifty years. An area of short-grass land in which the physical conditions approach more nearly those of wire-grass land, if broken, will be possessed after the preliminary weed stage by plants of the wire-grass association (Pl. II, fig. 2), and will then gradually return to the short grasses, the time required being twenty to forty years.

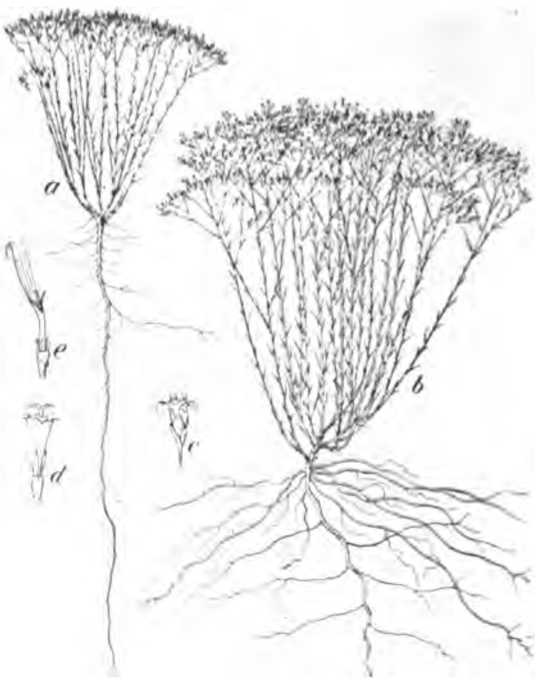


FIG. 22.—*Gutierrezia sarothrae*. Young plant showing deep taproot, *a*; old plant showing better development of lateral roots, *b*; flower head, *c*; disk flower, *d*; ray flower, *e*.

Breaking done on wire-grass land (p. 52) will result in the establishment of a vegetation such as usually characterizes a still lighter type of soil. Many plants from the bunch-grass and the sand-hills mixed associations enter, and in the early stages of this succession bunch-grass itself quite generally occurs. The vegetation will ordinarily return to the wire-grass type in fifteen to thirty years.

[a] If wheat-grass is abundant, breaking often improves the range, but as a rule the range is damaged.

Wherever land characterized by the bunch-grass (p. 54) or the ıd-hills mixed associations (p. 58) is broken a blow-out (p. 60 d Pl. VI, fig. 1) may result. This, however, is unusual, although ›re is great danger if the land is plowed in the fall of the year. ually the weed stage most prominent the ›t year or so, but the tive grasses soon re- in possession and the ccession is completed a much shorter time an on the heavier types land.

It will thus be seen ıat when the vegeta- on of each of the plant ›sociations is destroyed y breaking it will be ›llowed, after the weed ›age, by vegetation ıaracteristic of a lighter ype of soil, and also ıat this vegetation is hat characteristic of an arlier stage in the nat- ral succession.

FIG. 23.—*Artemisia frigida*. Plant, showing habit, *a;* flower head, *b;* single flower, *c;* leaf, *d*.

A knowledge of the onditions indicated by hese secondary succes- ions which result from ›reaking is a useful guide n estimating the com- ›arative value of land. For example, short-grass land which when broken reverts to wire-grass should be regarded as much more favorable for agricultural ›urposes than short-grass land which when broken becomes occupied ›y Gutierrezia and Artemisia.

PLANT COMPETITION AND THE REASONS FOR THE SUCCESSIONS.

The successions brought about by breaking are probably due entirely to the changed physical conditions. The destruction of the

entire surface vegetation by plowing brings about a condition which is much more favorable for the storage of water in the soil than previously existed. Repeated observations in the field show that after a rain the water penetrates much deeper on land that has been broken than on that covered by the undisturbed native sod. This increase in the depth of penetration is brought about partly as a result of the great reduction in the quantity of plant growth and the consequent higher water content of the soil previous to the rain and partly as a result of decreased run-off on the broken land as compared with the native sod.

Breaking destroys the vegetation almost entirely, thus leaving the area open for the entrance of new plants. Naturally, the annual weeds, with their exceptional ability to seed new land and to grow rapidly at almost any period of the year when temperature and water content are favorable, are first to appear. The species which may enter into this stage are so numerous and their appearance is so dependent upon the chances of a supply of seed being near at hand that this stage of the succession has been passed over with very little discussion.[a]

If after short grass is turned under the Gutierrezia-Artemisia type of vegetation becomes established it is probable that in the deeper layers of the soil conditions are more favorable for the growth of deep-rooted plants than they were previous to breaking. The subsequent reestablishment of the short grasses on such land and the resulting disappearance of the Gutierrezia and Artemisia are likewise results of changes in the physical condition. The surface soil gradually becomes hard again and somewhat puddled, resulting in decreased water penetration and increased run-off. Measurement of the rate of penetration shows a great increase when the surface of soil of this character is loosened or removed. Another condition which is of great importance here is the direct competition for water between the short grasses and the deeper rooted plants of the Gutierrezia-Artemisia association. Many of the latter, such as Actinella, Eriogonum, etc., have practically no surface roots. As the short grasses gradually enter, their shallow roots have the first chance at the moisture, which after a rain is held for some time in the surface layers of the soil and passes but slowly to deeper layers (p. 33).

The younger plants of Gutierrezia have a very deep tap root and almost no lateral roots (fig. 22, *a*, p. 66). The short grasses are consequently able to kill out this plant by consuming the available water before it can reach the roots of the Gutierrezia. This condition comes about gradually, however, and many of the older Gutierrezia plants will be found to maintain themselves for a long

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[a] See footnote, p. 41.

eriod in the short-grass cover. But an examination of the roots of uch plants will show that the root habit has become greatly changed fig. 22, *b*). Many lateral roots have developed which feed largely n the surface layers of the soil and are in this way able to compete vith the roots of the short grasses. The long season required for Gutierrezia to complete its development and ripen seed is probably ne of the reasons why, notwithstanding its ability to modify its oot system, it does not succeed better in competition with the hort grasses.

When wire-grass vegetation becomes established upon short-grass and that has been broken the plants of this association are likely o dominate for a number of years. But the cover is never very lose, and in the interspaces the short grasses soon become estabished. Wire-grass is deep rooted and feeds in layers of the soil ower than those which sustain the short grasses. The wire-grass s gradually shut out by the short grasses, which absorb the water in he surface layers, leaving little or none for deeper rooted plants. It is clear that with a limited water supply the short grasses, having roots which completely occupy the surface soil, are able to drive out the deeper rooted plants with which they come into competition.

Wire-grass land affords a good illustration of a balanced condition—a condition of continual stress between the short grasses and the deeper rooted plants (fig. 14, p. 51). The fact that water is available in the deeper layers of the soil is demonstrated by the presence of many deep-rooted plants on this land, and it might be supposed that under these conditions bunch-grass would take possession. But in this connection we should consider that bunch-grass requires a long season, approximately one hundred and fifteen days, to complete its growth, while wire-grass requires only about forty days to ripen seed. Even *Psoralea tenuiflora* (fig. 12, p. 46), which is one of the long-season plants of the wire-grass association, requires only about eighty days. In the wire-grass areas there is less water in the deeper layers than on bunch-grass land, and it is in all probability exhausted much earlier in the season. The plants of short-grass land are, as a rule, short-season plants, grama grass requiring sixty days to mature, while buffalo grass requires only about thirty-six days. The plants of the wire grass association are intermediate in length of season. Bunch-grass and many of the species associated with it require a long growing period, and a sufficient water supply is necessary throughout the summer.

The behavior of the native vegetation indicates clearly that the conditions favorable for growth on short-grass land last for only a comparatively short season, beginning with the spring rains and extending to about the middle of summer. The more important

plants of this association can mature in sixty days or less and many of them in less than forty days. On wire-grass land the season is somewhat longer, while on bunch-grass land it is almost twice as long, the principal species requiring considerably over one hundred days to mature seed.

The physical conditions on bunch-grass land are favorable for the development of wire-grass and of the short grasses as well as of bunch-grass. The two former are kept down by direct competition. by being shaded by the taller bunch-grass. The physical conditions on wire-grass land are favorable for the short grasses, and these are kept down in the same way by the wire-grass. On the other hand, the physical conditions encountered on the short-grass land are decidedly unfavorable for bunch-grass and often for wire-grass as well.

Grazing and fires bring about conditions which are especially interesting from the standpoint of plant competition. Working together they keep down the bunch-grass and similar tall-growing species, thus allowing the short grasses to maintain themselves notwithstanding the fact that the other conditions are favorable for the growth of deep-rooted plants. The effect of close grazing on land occupied by the sand-hills mixed association (Pl. V, fig. 1), which often results in establishing a pure short-grass vegetation between the plants of sand sage, offers a most interesting example of this condition. The sage, which is not eaten, develops into large bushes, owing, doubtless, to the fact that it has no competitors for the water in the deeper layers of the soil. The short grasses also grow well on such land, since the taller grasses are kept down by grazing and can not displace the short grasses by overtopping them.

CROP PRODUCTION ON LAND CHARACTERIZED BY DIFFERENT TYPES OF VEGETATION.

CROP PRODUCTION ON SHORT-GRASS LAND.

PHYSICAL CONDITIONS OF CULTIVATED SHORT-GRASS LAND.

The physical conditions indicated by the presence of short grasses have already been discussed on pages 27 to 40. The water supply available for the plant is greatest in June and rapidly decreases in July, August, and September. The native plants, almost without exception, require only a short growing season. In eastern Colorado land characterized by short-grass vegetation is a loam which will easily take up 25 per cent of the water after a rain. The water penetrates slowly, and as a result of the ability of the soil to hold a high

ercentage moisture is usually confined to the upper foot or two of oil. Wherever the land is kept free from vegetation, as in summer llage without crop, loss of water is greatly retarded and water may e conserved for a fall crop.

WATER PENETRATION.

Measurements were made to determine the comparative penetration and run-off from cultivated land and from the native sod, care eing taken to avoid low places or places where there was a perceptile slope.[a]

On September 3, after a rainfall of 1.12 inches, very careful measurements were made at the Akron Dry-Land Experiment Farm, on 6 orn plats, 1 kafir plat, and 1 summer-tilled plat. The corn plats were all well cultivated and had received various treatments previous o spring planting to corn. The conditions represented a wide range f soil management and should, therefore, have given good averages. Each measurement was based upon three carefully selected samples which were chosen in places of average water penetration as shown y the depth to which the dark color of the moist soil extended. This ain was of a torrential character and conditions were most favorable or a high rate of run-off. The run-off at the base station in the hort-grass land, where the records of soil-moisture content were aken twice daily throughout the season, was the greatest recorded luring the whole period. The comparative results are given in Table X.

TABLE X.—*Penetration and run-off for short-grass sod and cultivated land at Akron, Colo., as a result of a 1.12-inch rain, September 3, 1909.*

Description of land.	Penetration.	Run-off.
	Per cent.	*Per cent.*
Short-grass sod at base station	45	55
Average for 8 cultivated plats	51	49

From these results, as well as from those recorded in another publication,[b] it is evident that run-off is a factor of great importance. The data here given show that the run-off on cultivated land was very great, in fact, almost as great as on the short-grass sod.

As a result of the heavy rain of 2.39 inches on July 7, the comparative data following were obtained.

[a] The penetration and run-off on land covered with short-grass vegetation are discussed in detail on p. 34.

[b] Briggs, L. J., and Belz, J. O. Dry Farming in Relation to Rainfall and Evaporation. Bulletin 188, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1910, p. 15.

TABLE XI.—*Penetration and run-off for short-grass sod and summer-tilled plat, Akron, Colo., as a result of a 2.39-inch rain July 7, 1909.*

Description of land.	Penetration.	Run-
	Per cent.	*Per cen*
Short-grass sod at base station	86	
Summer-tilled plat	48	

This high percentage of run-off from summer-tilled land accor with the results of previous measurements.[a] Many observations i the field show that the penetration of rain water into a dust mul such as is often maintained on a summer-tilled field, is very slow, a that this mulch is almost as effective a preventive of water penetr tion as of evaporation. On the other hand, observations of the pen tration on newly plowed sod and on lumpy, cultivated land show th when the surface is in a rough condition water enters rapidly. It desirable, especially during the rainy season, to have the soil in su condition as to prevent run-off as far as possible, and to develop dust mulch only when the soil is already well supplied with water.

BEHAVIOR OF CROP PLANTS.

Because of the fertility of the soil, cultivated crops on short-gra land usually produce a luxuriant growth in the spring and early sum mer. The water supply, although high enough in percentage, do not extend to any considerable depth and the crop is in very mu the same condition as that of potted plants where, although the wat supply is sufficient temporarily, it is soon exhausted by rapid grow and the plant is suddenly left with no reserve. The very rapidi and luxuriance of the early growth exhaust the water supply all t more rapidly, and the fact that the water is limited to a shallow su face layer of soil means that loss by direct evaporation is relativ high. During the latter part of July conditions are almost sure occur which will cause a sudden drying up of the crop. This cond tion takes place so suddenly that it is practically impossible for a crop to adjust itself rapidly enough to meet this change. Corn especially liable to be destroyed at this critical period, for it posses little ability to recover after drought. Wheat crops, particularly t fall wheats, may be ripened before the period of drought comes o but this does not always happen, and in especially unfavorable yea even the small grains will be an entire failure. On the other han

[a] Briggs and Belz, op. cit., p. 15. The comparatively low percentage of run-off at t base station has already been discussed. (See p. 34.)

ring wet years or years in which a moderate rainfall is unusually ll distributed, crop production on short-grass land is greater than any other type of land in eastern Colorado.

The frequent failures of crops on short-grass land are largely due lack of sufficient rainfall or to its unequal distribution. Another ison is the fact that during torrential rains by no means all of the nfall is stored in the soil, a great amount running off, while that ich enters the soil remains near the surface and is rapidly lost by aporation. A further point of importance is that because of the undance of plant food the crop often grows too luxuriantly in the ginning and consequently uses up at too early a period in its growth e moisture which should have sufficed for the entire season.[a] Under ese conditions a field of wheat which produces a good stand of straw ay produce no grain, the excessive growth of straw having exhausted e water supply before the grain could ripen. The same is true of her crops, especially corn, which often dries out just at the period earing. In this connection it is interesting to note that in this gion when land is manured the resulting stimulation of growth most always exhausts the water supply too rapidly. Hence a genal impression prevails throughout the Great Plains region, based actual experience, that manure will cause a crop to burn up; and is, therefore, only rarely used. These facts make it necessary at the importance of thin seeding be emphasized. Where too any seeds are planted the crop uses up the total water supply before iy of the plants mature. Thin planting, on the other hand, leaves greater water supply for each individual plant. These facts also idicate that dwarf strains are better adapted to short-grass land ian the larger and more luxuriant varieties.

Reference to the rainfall records for eastern Colorado (p. 28) will iow that during average years the water supply decreases rapidly om July to November. The increased heat in July and August iakes this a period of the year when drought is to be expected. he natural plant cover consists chiefly of species that complete heir growth by the middle of July. These conditions of climate nd soil, illustrated by the behavior of the native vegetation, show hat short-grass land is best adapted to what might be termed early-season crops"—crops which mature early in July. The proluction of later crops during average years is more or less uncertain ecause of the tendency for drought to occur after the middle of ummer. Among the most successful later crops are sorgo, milo, etc.,

[a] See Chilcott, E. C., "A Study of Cultivation Methods and Crop Rotations for the Great Plains Area," Bulletin 187, Bureau of Plant Industry, U. S. Dept. of Agriculure, 1910, p. 19.

which by their slow growth during the early season conserve the soil moisture and on this account are enabled to continue growth longer than other crops which rapidly exhaust the soil moisture.

Under natural conditions short-grass land is not at all adapted to deep-rooted crops, and clean cultivation is required to establish conditions favorable for such plants. Tillage on short-grass land always produces more favorable water relations by conserving the moisture which enters the soil.

Many timber claims are found in eastern Colorado, but few of them occur on short-grass land. Yet in some places trees have done surprisingly well on such land. While these trees grow on land which was previously covered with the short grasses, the land on which the trees stand now produces wire-grass, as a result of the breaking done when the trees were planted. On this hard type of land the most successful trees seem to be the ash and the box elder, although many other species, especially the elm, hackberry, and honey locust, have grown fairly well.

With clean cultivation and with the trees set far apart, orchards of apple, plum, cherry, pear, and peach trees have been established in several places. The most successful tree growth, however, occurs in land where wire-grass or Psoralea, or both, are rather abundantly mixed with the short grasses. Such trees as willow and cottonwood are not at all adapted to the conditions existing on short-grass land.

Under conditions such as these there seems little to justify the assumption that alfalfa will last for many years on short-grass land, even if a stand can be secured. It is a very deep-rooted plant and not at all adapted to the conditions above described. That water supply is the principal limiting factor should always be borne in mind in considering crop production in this region. A field of rapidly growing alfalfa such as may be seen in irrigated sections would exhaust the total water supply of the soil in a few days. Yet it is possible that alfalfa, when not too thickly seeded or, preferably, planted in rows or hills with intertillage, can be made a profitable crop on short-grass land.

The impression that a very large yield can be obtained provided especially adapted crop plants be grown also seems unfounded, for with the limited water supply even the native plants and weeds never produce a great amount of dry matter in a single season (p. 81). The best estimates obtainable as to the amount of water required to produce a pound of dry matter make it probable that with the average seasonal rainfall of eastern Colorado it would be impossible to produce more than 3 tons per acre, even if no water were evaporated directly from the soil and there were no run-off.

CROP PRODUCTION ON WIRE-GRASS LAND.

PHYSICAL CONDITIONS OF CULTIVATED WIRE-GRASS LAND.

The physical conditions on wire-grass land (p. 50) are very different from those of short-grass land (p. 27). The soil, being of a much lighter texture, absorbs practically all the rain that falls upon it and permits the moisture to penetrate to greater depths. Consequently there is a bed of moist soil extending to a depth of several feet. The presence in the native vegetation of many deep-rooted plants indicates this condition. Under cultivation it is probable that water penetrates still more easily than under natural conditions. Furthermore, the loss of water by evaporation is retarded to a very great extent by cultivation. As a result we find here a condition very favorable for the production of crops either shallow or deep-rooted.

Since water is distributed to considerable depths in this type of soil, the exhaustion of the water supply in the immediate vicinity of the roots is not necessarily fatal to the plant, for there is a large area of moist soil into which roots can penetrate or from which water can move slowly to where it is within reach of the root systems, and this area serves as a reserve in time of drought. The loss of water by evaporation after a rain is not so great on wire-grass land as on short-grass land and the conditions for the conservation of the water supply through the whole season are much better.

BEHAVIOR OF CROP PLANTS.

Taking one year with another, wire-grass land is the best in the region for agricultural purposes. The yield in wet years is almost equal to that of the short-grass land and during the average year it is much better. Often when crops fail entirely on short-grass land wire-grass land will produce good crops. The conditions on land of this type are such as to favor deep-rooted crop plants. It is believed that alfalfa, especially if planted in rows or hills and not too close together, will here find excellent conditions for its growth.

Successful tree claims are more numerous on this type of land than on land of any other type. Among the species that succeed best are the elm, ash, box elder, black locust, and honey locust. The finest grove of trees seen by the writer in this portion of the Great Plains was on this type of land at Cope, Colo. Cottonwood and poplar, as well as a great variety of fruit trees, were growing successfully in this grove. There is a possibility that at this place the trees are subirrigated by water that seeps down from the sand hills, yet this seems unlikely, for during the latter part of the summer of 1909 many of the trees in this plantation, especially those which were in competition with the grasses, suffered so severely from drought that their

foliage was badly wilted. If subirrigation were taking place, this would hardly have occurred, for many of the trees in places known to have no subirrigation were in better condition, although subjected to the same drought.

In general, it may be stated that on wire-grass land the water penetrates to a considerable depth and that the conditions are very favorable for the development of deep-rooted plants. The effect of cultivation on moisture conservation is not so great as on short-grass land, but is still rather marked. The degree to which the soil texture favors the penetration and conservation of water makes this land the best type for agricultural purposes found in eastern Colorado. Under the same climatic conditions crops will mature easily on this type of land when on short-grass land they are entirely burned.

CROP PRODUCTION ON BUNCH-GRASS LAND.

PHYSICAL CONDITIONS OF CULTIVATED BUNCH-GRASS LAND.

The physical conditions indicated by bunch-grass vegetation (p. 55) are those most favorable for the growth of deep-rooted plants. In eastern Colorado this vegetation indicates a sandy soil in which water penetrates very readily and to great depths. The cultivation of this soil does not materially facilitate water penetration nor diminish the rate of water loss. We have under natural conditions a water relation which is most favorable for the growth of plants (Pl. IV, fig. 2) with deep and extensive root systems.

BEHAVIOR OF CROP PLANTS.

During wet years the ease with which water percolates makes it practically impossible for the soil to become too moist for the best growth conditions. During dry years growth is slow on this type of land, and as a consequence the water is only slowly exhausted by the plants. Because of the great depths to which water penetrates and is stored in the soil, plants are able to continue growth during a long period of drought by the gradual extension of their root systems. Under the same climatic conditions bunch-grass land can produce a fair crop when water is entirely lacking in short-grass land. In fact, the bunch-grass land during excessive drought is the best type for crop production, but during average years it is considerably inferior to wire-grass land, largely because the latter is richer in plant food. In a series of pot experiments, soil from short-grass land produced much the best growth, wire-grass land ranked next, bunch-grass land next, soil from the sand-hills mixed association next, while soil from the blow-out association produced the least growth. This is directly in accordance with the production of crops under field conditions when each type of soil is well supplied with water.

...ch-grass land has the further disadvantage of being liable to ...w badly. Hence very little attempt has been made to utilize this ...l for small-grain crops. The most successful crops have been ...n, sorgo, milo, etc.

...n eastern Colorado land of this type and that of the wire-grass type ...ften referred to as "corn land," since by far the greater yield of ...s crop is produced on farms which are on either bunch-grass or ...e-grass land. During the falls of 1907 and of 1908 many good fields ...corn were seen on bunch-grass and wire-grass land, while on the ...jacent short-grass land the crop was an entire failure.

Trees of many different kinds are commonly grown on bunch-grass ...nd. The cottonwood, willow, Carolina poplar, soft or silver maple, ...alnut, catalpa, ash, elm, box elder, honey locust, black locust, cherry, ...ple, plum, Russian mulberry, etc., make a good growth on land of ...is type, and even on land marked by the sand-hills mixed vegetation ... 58), and occasionally by the blow-out type (p. 60 and Pl. VI, ... 1) of vegetation. Conditions on bunch-grass land are favorable ...r deep-rooted crops, such as trees and alfalfa. Very successful ...elds of alfalfa are here and there found, especially where it has been ...eded in rows and where other plants are not allowed to compete ...ith it for the soil water.

PRECAUTIONS NECESSARY IN HANDLING BUNCH-GRASS LAND.

Ordinary moisture-conservation methods of tillage should never ...e practiced on bunch-grass land, since nothing is to be gained and ...here is every chance of loss due to blowing. As a result of many ...bservations in the field, the following methods are suggested:

(1) The land should be laid out in long narrow fields running east ...nd west.[a]

(2) The crops should be so arranged that two adjacent fields are not prepared for seeding at the same time and the soil in both thus left without protection.

(3) Because of the value for hay of the natural growth of grasses occasional or even alternate fields may be left undisturbed for this purpose.

(4) By proper care in arranging the crops those which do not afford a sufficient cover to prevent the soil from blowing can be protected by adjacent crops which do prevent soil movement.

(5) When practicable, as much of the straw or stubble should be left on the field as will be necessary to prevent blowing during winter and early spring.

[a] As indicated by the blow-outs the winds which do the most damage are from a little west of north and a little east of south, hence approximately at right angles to narrow fields running east and west.

(6) Since cultivation does not noticeably increase water conservation, only such cultivation should be done as is necessary to keep down weeds.

(7) When practicable, cultivation should be done only when the surface soil is damp.

(8) If the soil has begun to blow, cultivation deep enough to bring moist soil to the surface will often check it.

(9) Care should be taken to avoid breaking the native sod on crests or hilltops.

(10) Corn, sorgo, milo, and deep-rooted crops, especially perennials, such as trees and alfalfa, should be tried.

A COMPARISON OF THE CONDITIONS INDICATED BY SHORT-GRASS, WIRE-GRASS, AND BUNCH-GRASS VEGETATION.

THE SOIL-MOISTURE RELATIONS INDICATED.

In comparing the conditions found on short-grass, wire-grass, and bunch-grass land, respectively, in the limited area especially considered here, we find that they are largely expressed in the different water relations of the different soils. The rates of water penetration as measured on these three types of land under the same climatic conditions during the summer of 1909, and also comparisons of typical samples of these soils as to other water relations—moisture equivalent and nonavailable soil moisture for Kubanka wheat—are given in Table XII.

TABLE XII.—*Comparison of water relations of short-grass, wire-grass, and bunch-grass land.*[a]

Item of comparison.	Short-grass land.	Wire-grass land.	Bunch-grass land.
Time required for one-half inch of water to penetrate......seconds..	540	150	40
Moisture equivalent.........per cent..	18.1	9.7	4.7
Nonavailable moisture for Kubanka wheat.........do....	9.6	4.8	2.6

[a] See footnote, p. 18, for a definition of the terms "moisture equivalent" and "nonavailable moisture." It will be noted that the nonavailable water content bears a practically constant ratio to the moisture equivalent for these three types of soil. This relationship has been under investigation during the past two years by Dr. L. J. Briggs and the writer, and will be fully discussed in a publication now in preparation.

Since these soils weigh approximately 84, 93, and 96 pounds, respectively, per cubic foot, we can estimate the depth of penetration of any given amount of rainfall, provided we know the water content of the soil before and after the rain. We may assume, for the sake of illustration, that the water content of the soil before the rain is the nonavailable moisture for Kubanka wheat, and after a rain that the water content is equal to the moisture equivalent. The depth to which water would penetrate in the different soils under these conditions,

provided none were lost by run-off or immediate evaporation, is shown in Table XIII.

TABLE XIII.—*Estimated depth of water penetration, assuming that the water content of the soil to the depth of penetration is raised by the added moisture from the nonavailable moisture to the moisture equivalent.*

As a result of—	Depth of penetration in inches.		
	Short-grass land.	Wire-grass land.	Bunch-grass land.
One inch of rain	8.7	13.7	30.9
The average seasonal rainfall, April to July, 10.35 inches	90	142	320

Differences in the depth of moisture penetration are to a great extent the causes of the differences in the ability of crops to resist drought on land of the different types. Where the moisture is held near the surface it is not only more readily lost by direct evaporation but can be rapidly exhausted by the plants, whose roots reach to every part of the moist layer of the soil. Where the water is distributed to greater depths it is not only less readily lost but can not be exhausted so quickly by growing plants.

It should be noted that streams originating in the sand hills are permanent and do not dry up during periods of drought. This indicates that water is lost by percolating beyond the reach of the plant roots. However, the amount which is lost in this way is probably almost negligible as compared with that dissipated by evaporation and transpiration.

In this region the soils are often very dry in the fall of the year and continue so until early spring. From repeated measurements the data in the first column of figures of Table XIV are given as the approximate water content of the top foot of soil at the end of the dry season just before the spring rains begin.

It will be seen from the figures in Table XII and the first column of figures in Table XIV that something more than the quantity of water shown in the three right-hand columns of Table XIV must be added to each soil before any will become available for the plant.

TABLE XIV.—*Water status at end of dry season for three kinds of soil.*

Kind of soil.	Percentage of water present in surface foot of soil.	Maximum percentage and quantities of water which can be added before any will become available to the plant.		
		Percentage.	Pounds of water per cubic foot of soil.	Inches of water per foot of soil in depth.
Short-grass land	5.0	4.6	3.86	0.74
Wire-grass land	2.7	2.1	1.95	.37
Bunch-grass land	1.3	1.3	1.24	.24

From the above data it is evident that in this region of deficient rainfall the lighter soil offers a more favorable moisture condition than does the heavier soil, even when an equal amount of water penetrates the two soils. When we consider that the run-off on the heavy land is very great and that the rate of penetration is many times less rapid than on the lighter land, the superiority of the latter becomes still more evident.[a]

THE SOIL FERTILITY INDICATED.

Observations in the field as well as pot cultures show that when water is supplied in sufficient quantity short-grass land is most productive, the next in order being wire-grass, then bunch-grass, sandhills mixed, and blow-out land, in the order named; but under ordinary conditions in the field, where the water supply is usually the limiting factor, the order of productivity is by no means that given above, for during dry years bunch-grass land and wire-grass land are much more productive than short-grass land.

Of interest in this connection is the probable duration of the fertility of the soils marked by the different plant associations. Hilgard (Soils, 1906, p. 86) states that in arid and semiarid regions sand is not to be regarded as inferior to other soils in fertility and that there is no reason to suppose that its productiveness is not as lasting as that of the "strong clay soils of the humid regions." The soil, even in the bunch-grass areas, is often dark in color, owing to the presence of a certain amount of humus, and contains a high percentage of the mineral material found in the original rock. In choosing land for farming it would be well to give some attention to the color of the sand, avoiding the lighter colored sand that is commonly found where the blow-out association occurs.

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[a] In a region such as the Great Plains where the rainfall comes during the growing season, the superiority of light over heavy land is probably much greater than in regions of winter rainfall. As a reservoir, the heavy land will hold much more water per cubic foot than light land. Winter rain which enters the soil can be protected by a dust mulch and held in a heavy soil for a long period. J. Widtsoe (The Present Status of Arid Farming in the Great Basin, Official Proceedings of the Dry-Land Congress, 1907, p. 134) states that in Utah "It matters little whether the soil is a sand, a clay, or a loam." But even in this region of winter rainfall the most successful dry farming was originally done on sandy soil. Powell (Report of the Lands of the Arid Region of the United States, with a more detailed account of the lands of Utah, Department of the Interior, 1879, p. 78), in discussing the "Sand Ridge," "south of Ogden and east of Salt Lake," states that "In these localities, and so far as I am aware, in all others where dry land has been successfully farmed, the soil is sandy, and this appears to be an essential condition." In the Great Plains region the summer rainfall makes conditions much more favorable on the lighter land. The condition is very well expressed by Marguerite R. Fink ("Dry Farming," A Homesteader, Official Proceedings Third Dry-Farming Congress, 1909, p. 237): "By experiment we find that clay land will give a luxuriant growth, but it will not ripen, so sandy loam or even a distinctly sandy soil is to be preferred."

AMOUNT OF NATIVE GROWTH PRODUCED.

The geographical distribution of the plant associations and the nount of native growth produced shows that as we pass from the ·airie region westward to the more arid region sand becomes relavely a better and better substratum for plants as compared with ıe heavier soil types. (See pp. 11, 12, and 24.) The bunch-grass sociation, which produces the largest quantity of dry matter and hich in eastern Kansas is able to maintain itself on loam land, is nited largely to the sand in eastern Colorado. The wire-grass sociation, which succeeds on a loam soil in central Kansas, is found ı sandy loam in eastern Colorado. This distribution of the native ›getation in eastern Colorado indicates most clearly that the contions for growth are more uniformly good on sand than on hard nds. The production of dry matter by the native plant cover ıries greatly from year to year. Measurements on August 23, 1909, the total dry matter, based on croppings of typical square-yard :eas and computed in pounds per acre for the sake of convenience ı comparison, are as follows: Short-grass land (ordinary cover), 16 pounds; short-grass land (exceptionally close cover), 400 pounds; unch-grass land (ordinary cover), 840 pounds.[a]

SOIL BLOWING.

It should be noted that in land characterized by the bunch-grass nd the sand-hills mixed associations the chief difficulty in producing rops results from the blowing of the soil. The wind by moving the ınd not only destroys the young growing crop, but occasionally ›moves the entire surface layer of the soil. Under natural conitions, where the native sod is undisturbed, this unfavorable condiion does not play a part. Consequently, although sand land may roduce a much heavier yield of native growth, it does not necesırily follow that it will become proportionately better farming land.

MOISTURE RELATIONS AND CROP PRODUCTION ON HEAVY AND ON LIGHT LANDS.

The physical data given in tables XII to XIV, inclusive, confirm he observations based on the growth of native plants as well as f cultivated crops, that in a region of deficient water supply the ghter soil presents safer conditions for crop production during verage years than does the heavier soil. This is largely due to the

[a] From the bunch-grass sample all dead stems, which amounted to an additional 100 pounds per acre, were removed. Many of these dry stems were produced in rmer years and were removed in order to reduce the weight to that actually produced uring the season when the cropping was made. The short-grass samples contained l of the plant material above the surface of the soil, so that the above comparison really too favorable to land of this type.

differences in moisture relations, but must be partly explained as due to the fact that cultivated plants do not grow so large nor use so much water on sand as on the hard land, and they are, on this account, much more likely to mature. The cultivation of hard land can not wholly overcome these differences. The loosening up due to cultivation will increase rather than decrease the water-holding capacity of the upper soil layer. It can, therefore, increase the depth of water penetration and bring about the storing of a greater amount of soil moisture in the lower depths only by reducing run-off, lowering the rate of evaporation, and preventing plant growth. On heavy land crop plants will be stimulated to rapid growth by every rainfall that is sufficient to furnish a good supply of water. But this supply will be limited to the shallow layer of the soil that is occupied by the roots. Drought will do far more damage under these conditions than it would to a crop on lighter land, which has a much deeper layer of moist soil from which to draw its water supply and on which the growth is less luxuriant.

SUMMARY.

(1) The natural vegetation is largely used to indicate the agricultural capabilities of land, but there are many possibilities of error, as this indicator is ordinarily employed.

(2) The object of the present publication is to show how this indicator may be employed accurately for the ready classification of new land.

(3) By indicating clearly the environmental conditions which prevail the native vegetation is of great value, not only in the classification of land, but also as an indicator of the kind of crop and method of culture that are most likely to succeed under the given conditions.

(4) Differences in the vegetation can be used to indicate changes in one factor of the environment only when all the other factors remain unchanged.

(5) Correlations with soil moisture are usually more easily established than with any other one factor, since it is through this factor that rainfall, evaporation, and the physical character of the soil chiefly affect the plant.

(6) Since plant growth is the ultimate measure of the suitability of the physical environment, the character, growth, and condition of the native vegetation are the best possible indicators of conditions favorable or unfavorable to crop production on land where crops have not yet been produced.

(7) The entire plant cover is a better indicator than the presence or condition of a single species, since in it we have a record which is

as stable as the most stable species and as sensitive as the most exacting plant.

(8) The results described in the present paper are based upon a detailed study of the natural vegetation of Washington and Yuma counties, in eastern Colorado, and upon more general studies made throughout the Great Plains region.

(9) The chief plant associations of eastern Colorado which indicate land of agricultural value are the grama–buffalo-grass association and the wire-grass association (both of which belong to the short-grass formation) and the bunch-grass association and the sand-hills mixed association (both of which belong to the prairie-grass formation).

(10) The chief vegetation types of eastern Colorado which indicate nonagricultural land are the lichen formation, the Gutierrezia-Artemisia association of the short-grass formation, and the blow-out association of the prairie-grass formation.

(11) Of the associations indicating land of agricultural value in eastern Colorado, the grama–buffalo-grass association is most extensive, occupying the greater part of the hard land. The bunch-grass and the sand-hills mixed associations occur only in the sand-hill regions, while the wire-grass association occurs on land of intermediate character.

(12) In eastern Colorado the rainfall records show that the average monthly rainfall is greatest during the period April to August. The increased heat in July and August makes it almost certain that drought will occur in these months. September and the later fall months have normally very little rainfall, and fall-sown grain often fails to germinate unless planted on land in which water from rains earlier in the season has been conserved by summer tillage.

(13) Measurements show that from grama–buffalo-grass land a great amount of water runs off and does not enter the soil.

(14) Soil-moisture determinations in this type of land show that even during periods of more than normal rainfall available soil moisture is limited to a few inches of the surface soil.

(15) On this account the vegetation is composed largely of short grasses which have a great number of roots limited to the surface foot or two of the soil.

(16) Moisture, even in the surface few inches of the soil, is often lacking except during a few weeks in spring and early summer. The short grasses have a comparatively short growing season.

(17) Deep-rooted species are shut out by the lack of soil moisture in the deeper layers of the soil and later-season plants are excluded because available moisture is usually lacking, even in the surface layers, during late summer and autumn.

(18) An open cover of the short grasses indicates conditions less favorable for crop production than a close cover.

(19) The presence of deeper rooted plants mingled with the short-grass vegetation indicates better conditions for crop production than those found where the cover is purely of the short grasses.

(20) The occurrence among the short grasses of plants characteristic of the associations which indicate land without agricultural value suggests a less favorable condition for crop production than where short grasses only are found.

(21) The presence of the wire-grass association indicates that there is a considerable amount of water in the deeper layers of the soil, owing to the lesser run-off and to the fact that the lighter soil permits deeper penetration.

(22) Conditions indicated by the wire-grass association are favorable for both shallow-rooted and deep-rooted plants and for a considerably longer period of growth than those indicated by the grama-buffalo-grass association.

(23) The bunch-grass association indicates a soil that is moist to a considerable depth. Here conditions are more favorable for deep-rooted and late-season plants than in land characterized by either the short-grass or the wire-grass vegetation.

(24) The sand-hills mixed association indicates conditions very similar to those of the bunch-grass association, but rather less favorable, as shown by the smaller amount of plant growth.

(25) The short-grass vegetation represents the final stage in a succession which may begin with the lichen formation and pass through the Gutierrezia-Artemisia association. Or the succession may begin with the blow-out association and pass through the sand-hills mixed and the bunch-grass associations and (by the aid of fires and grazing) through the wire-grass association to a pure short-grass vegetation.

(26) When short-grass land is left without cultivation after breaking it will be revegetated by either the wire-grass or the Gutierrezia-Artemisia association, depending upon the physical conditions.

(27) The vegetation which establishes itself after wire-grass is turned under is that which is naturally characteristic of a lighter soil.

(28) When the native sod of the bunch-grass or the sand-hills mixed associations is broken, a blow-out may result. Usually, however, the original vegetation is soon reestablished.

(29) When the vegetation of any of the plant associations is destroyed by breaking and the land is then abandoned the land will be reoccupied (after a weed stage) by vegetation that is characteristic both of a lighter type of soil and of an earlier stage in the natural

succession. These successions are the result of changes in the physical conditions brought about largely as a result of the destruction and reestablishment of the plant cover itself.

(30) The taller, deeper rooted plants are easily shut out by the shallow-rooted short grasses when the water that falls as rain is not sufficient to penetrate beyond the layer of soil occupied by the roots of the short grasses before it can be absorbed by them.

(31) Where water can readily penetrate below the depth ordinarily reached by the roots of the short grasses the conditions are favorable to the growth of deeper rooted and taller species, which shut out the short grasses by overshading them. This increased penetration of water may be due either to greater rainfall or to lighter soil texture.

(32) When well supplied with water short-grass land is the most productive under cultivation of any in eastern Colorado. During drought, however, crops suffer on this land sooner than on any other type.

(33) During exceptionally dry years bunch-grass land produces the best crops of any in eastern Colorado, but during wet years its production is surpassed by that of all others except the land characterized by the sand-hills mixed association. The soil under both of these types of vegetation is likely to blow badly.

(34) Wire-grass land represents a safe intermediate condition where in years of ample rainfall crop production compares not unfavorably with that on short-grass land and where, even during dry years, a fair crop can often be produced.

(35) One of the chief reasons for the superiority of light land over heavy land in eastern Colorado is that crop growth is rapid on the latter and that the total available supply of soil water lies near the plant roots, the crops, therefore, being in somewhat the same condition as potted plants. These conditions favor a rapid exhaustion of soil moisture and, consequently, bring about sudden drought. On the lighter land water is distributed to greater depths, the plant growth is slower, and plants, by gradually increasing their root area, can resist much longer periods of drought.

(36) Investigations of soil conditions, as well as actual observations of crops in the field and studies of the native plant cover, show that as we pass from the prairie westward to the more arid portion of the Great Plains the lighter soils present relatively more favorable moisture conditions and, therefore, conditions more favorable to plant growth than do the heavier types of land.

CONCLUSIONS.

It is believed that the evidence presented in the present paper justifies the conclusion that the character of the natural plant cover can be used as a reliable indicator of the conditions favorable or unfavor-

able for crop production, provided the relations between the vegetation and the environment are correctly interpreted.

On the Great Plains a pure short-grass cover indicates a condition of considerable run-off and of limited water penetration, the available moisture usually being confined during the greater part of the season to the first 2 feet of soil. Under cultivation these conditions are modified chiefly by retarding water loss, thus permitting the water to penetrate deeper into the soil. But the penetration is still so slight that the roots of the comparatively shallow-rooted small grains are usually able to occupy the entire depth of soil where water is stored and in time of drought are in much the same condition as potted plants. The rather rank growth on short-grass land made by crops early in the season also greatly increases loss of water by transpiration from the plants and may be instrumental in causing a total failure when dry weather sets in, although with a less vigorous growth the supply might have been fully adequate to the needs of the crop. The presence of a short-grass cover indicates a growing season that is shortened by the limitation of the water supply. Crops which mature early are therefore more likely to succeed on this type of land than crops that require a longer season. Such land is not at all adapted to deep-rooted crops unless the plants are grown far apart and with adequate intertillage. Summer tillage is often necessary to insure the germination of fall grains.

Wire-grass indicates land into which almost all the rainfall penetrates. Because of the lighter texture of the soil the water is distributed to a greater depth, and on this account the native vegetation is partly composed of deep-rooted plants. Under natural conditions evaporation from the soil is here a much less important factor than on short-grass land. The conditions are such that plant roots can not exhaust the soil water as quickly as on short-grass land. The moisture is distributed to a much greater depth, and when drought threatens plants are able to draw on the reserve found in the lower layers of the soil. On this account periods of drought cause much less damage to vegetation on this type of land than on short-grass land. Crop growth on wire-grass land, even during favorable years, is almost as good as on short-grass land, and during average and dry years much better crops are produced on wire-grass than on short-grass land. The native plant cover indicates a considerably longer growing season than on short-grass land, as well as a much more favorable condition for the production of deep-rooted plants.

On bunch-grass land the soil texture is such as to insure the penetration of practically all the water that falls. Cultivation does not seem to retard water loss to any perceptible extent, except by keeping

down the growth of weeds. Crop growth is much less luxuriant on this land than on short-grass land when well supplied with moisture. This retardation of growth itself aids in conserving the soil water. When periods of drought occur the roots of the plants can draw upon a large mass of soil which is supplied with available moisture and which serves as a storage reservoir for the crop. The result is that crops on this type of land are comparatively seldom burned up or even wilted by periods of drought. The native plants are such as require a very long season of growth and indicate conditions favorable for deep-rooted as well as late-season crops.

Crop failures occur oftenest on short-grass land; least often on bunch-grass land. The largest yields are obtained during favorable years on short-grass land; the smallest on bunch-grass land. During wet years short-grass land is best; during dry years bunch-grass land is best. Wire-grass land represents a safe intermediate condition, for in years of ample rainfall crop production upon it compares not unfavorably with that on short-grass land, and even during dry years a fair crop can often be produced.

Using the native vegetation as an indicator of the capabilities of crop production, we would class the type of land that is characterized by the wire-grass association year in and year out as the most valuable agricultural land in eastern Colorado. With it, or very close to it, should be classed that type of short-grass land which bears a considerable growth of wire-grass or of Psoralea, for the presence of these plants indicates conditions intermediate between those indicated by the typical wire-grass association and those indicated by the typical grama–buffalo-grass association.

Many of the older settlers in eastern Colorado have moved from short-grass land onto wire-grass land, or even onto bunch-grass land, where they claim there is much less likelihood of crop failure; but the newcomer in the region or the speculator almost invariably chooses the hard or short-grass land because it is darker in color and looks more like the soil he has been accustomed to farm successfully in the East. On this account short-grass land brings the highest price and changes hands oftenest, while wire-grass and bunch-grass lands are not so readily sold and bring much less per acre.

PLATES.

FIG. 1.—TYPICAL VIEW IN THE GRAMA-BUFFALO-GRASS ASSOCIATION, BURLINGTON, COLO.

FIG. 2.—TYPICAL VIEW IN THE WIRE-GRASS ASSOCIATION, YUMA, COLO.

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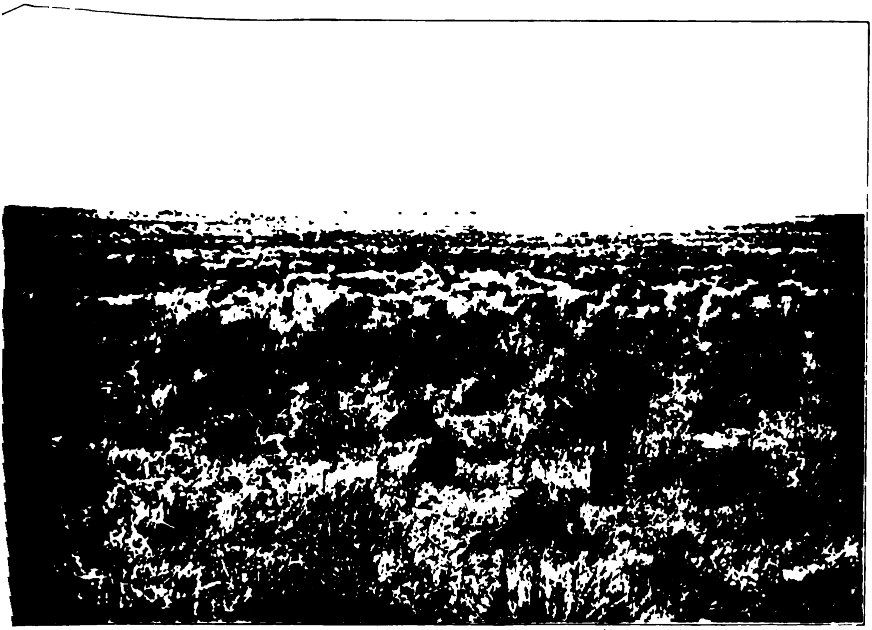
FIG. 1.—PSORALEA ON SHORT-GRASS LAND, YUMA, COLO.

FIG. 2.—WIRE-GRASS ON SHORT-GRASS LAND, VERNON, COLO.



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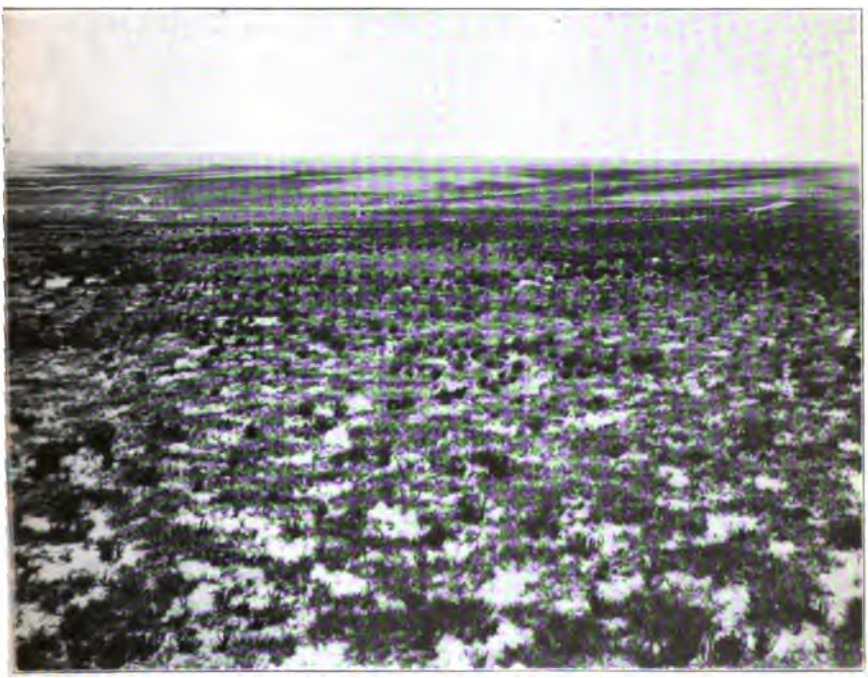

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 202.

B. T. GALLOWAY, *Chief of Bureau.*

THE SEEDLING-INARCH AND NURSE-PLANT METHODS OF PROPAGATION.

BY

GEORGE W. OLIVER, Plant Propagator.

Issued March 11, 1911.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

BUREAU OF PLANT INDUSTRY.

Chief of Bureau, BEVERLY T. GALLOWAY.
Assistant Chief of Bureau, WILLIAM A. TAYLOR.
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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., September 20, 1910.

Sir: I have the honor to transmit herewith a manuscript entitled "The Seedling-Inarch and Nurse-Plant Methods of Propagation," by Mr. George W. Oliver, Plant Propagator of this Bureau, and recommend that it be published as Bulletin No. 202 of the Bureau series.

Respectfully,

Wm. A. Taylor,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

INTRODUCTORY NOTE.

One of the most important factors in the creation of a plant industry which depends upon a perennial species is the rapid propagation of the plant. The possibility of bringing through the mails from any part of the world a few seeds of some rare plant is of relatively little moment if it is not backed up by adequate methods of quick reproduction from these few seeds through asexual propagation in order to produce large numbers of individuals for experimental trial. One of the greatest drawbacks of horticulture is the time required to test a new variety originated from seed, and any method which shortens the time required to make such tests must appeal to everyone, whether an originator of new varieties or a tester of them, as of the greatest value.

The seedling-inarch method which has been worked out by Mr. Oliver it is believed is destined to prove of the greatest importance not only in connection with the propagation of the tropical and subtropical fruits and ornamental plants with which this bulletin particularly deals (because it has been in his studies with them that he has come to realize its value), but in a very wide range of plant industries in which the early fruiting of a variety is very desirable. This shortening by a year or more of the time required for the fruiting of a new variety is believed to be a matter of such unusual importance as to be worthy of the widest publicity among all interested in the cultivation of plants. The discussion embodied in this bulletin, while it indicates the present stage of our studies of certain tropical-fruit industries, must be considered as having a much more general application than to these few new-fruit possibilities which are as yet little known to the American public.

DAVID FAIRCHILD,
Agricultural Explorer in Charge of
Foreign Seed and Plant Introduction.

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THE SEEDLING-INARCH AND NURSE-PLANT METHODS OF PROPAGATION.

INTRODUCTION.

While investigating the asexual propagation of some tropical fruit trees and other plants, at the request of Dr. B. T. Galloway, Chief of the Bureau of Plant Industry, it was discovered by the writer that a large number of hard-wooded shrubs and trees are capable of very rapid increase when propagated by processes which may be termed the seedling-inarch and nurse-plant methods.

These methods are inexpensive and, owing to their simplicity, may be used by persons without previous experience in the propagation of plants. By these methods the ever-increasing number of plant breeders will be enabled to save much time in determining the value of hard-wooded plants raised by means of hybridization. They can be used in manipulating seedlings of rare trees and shrubs intended for crossing, so that each plant will bloom in a much shorter time than if left to grow on its own roots. Seedlings of all hard-wooded plants resulting from collections made by travelers in foreign countries may thus be brought to the flowering stage and their value determined quickly.

The most remarkable feature of the new methods lies not only in their simplicity but also in the certainty of the unions which result. The writer has had very few unsuccessful unions and none among those classes of plants where the most suitable stocks are known and in common use. Not only is it possible to inarch a seedling a few weeks old to a large stock, but a moderate-sized seedling stock can be inarched to a shoot of a rare shrub or tree having the same diameter as the stem of the seedling. A satisfactory union may thus be induced where other methods of asexual propagation have invariably failed.

Rose seedlings resulting from crossing varieties have been inarched on manetti stocks when the seedlings were from 3 to 4 weeks old, and they produced maximum-sized flowers long in advance of those on seedling plants growing on their own roots. The rare finger lime, *Citrus australasica*, sometimes seen in a dwarf, sickly condition in

greenhouse collections, has borne fruit in two years after inarching on one of its congeners; and within nine months after flowering. hybrid seedlings between this citrus and a cultivated orange were in their turn inarched on 2-year-old lemon seedlings.

Very young seedlings of hundreds of other rare hard-wooded plants may be worked on the same or allied species or genera and their value determined much in advance of the time when they would flower on their own roots or on plants obtained by grafting or budding from the mature shoots of the seedlings.

Hard-wooded seedlings which need to be flowered in the shortest possible space of time, in order to determine their value, are used for inarching as soon as the first leaves attain a fairly firm texture, as, for example, in the case of the mangosteen. But when seedlings are used as stocks for the vegetative propagation of established varieties by uniting the stocks to small branches, then larger seedlings are used, as, for example, in the case of the mango.

The cultivation of the mango on a large scale has been delayed by our hitherto expensive and clumsy methods of propagation. In a recent bulletin issued by the Commissioner of Agriculture for the West Indies[a] the cost of producing large numbers of the finer varieties of cacao plants by inarching the small branches of these varieties to seedlings grown in bamboo pots is given at 6 cents each. In places where the mother mango trees have already been grown and are available for such use the owner will find the cost per inarched plant by the method here given to be reasonably small because the mango is as easy to inarch as the cacao.

Since the introduction by the Bureau of Plant Industry of more than a hundred varieties of the mango from India and other parts of the world, the cultivation of this much-esteemed fruit in the semitropical parts of the United States and elsewhere is gradually assuming important proportions. The propagation of young trees of those varieties which have been tested must necessarily be accomplished by asexual methods, as the finer Indian varieties do not come true from seeds.

The methods of propagation up to the present time have all been more or less faulty and cumbersome. The budding of seedlings in nursery rows requires the services of a trained propagator who knows what to do and how and when to do it. The average cultivator can hardly hope to acquire the skill necessary for the operation; moreover, there is always danger of loss from transplanting budded seedlings. Propagation by the older method of inarching on plants growing in 5 and 6 inch pots, sometimes for more than a year, is an expensive

[a] Jones, J. The Grafting of Cacao. Dominica, 1909.

ethod, necessitating the erection of strong staging around the parent ees for the accommodation of the plants in pots; moreover, the roots the seedlings become curled in the pots and make it difficult to velop a good root system for the future tree. The method here escribed has the advantage of being by far the easiest to use. Each rower may be his own propagator. With a helper to prepare the edlings he can easily inarch several hundred plants in a day.

Many plants belonging to various genera have the reputation of eing difficult to propagate asexually, but this is due mainly to ck of knowledge in regard to methods. The greater portion of hose dicotyledonous plants considered to be difficult or impossible propagate have this reputation because the methods successfully sed on other plants have been applied and found ineffective. There re doubtless easy methods of asexual propagation for all hardwooded dicotyledonous plants and even for some of the refractory monocotyledons.

The method described in the following pages appears to be the nly one which has been successfully applied to the rarest and most rized of tropical fruit trees, the mangosteen. This is a fruit of high quality, and its cultivation on a large scale has been delayed princially by the difficulties encountered in its asexual propagation. Material for the work of propagation is somewhat difficult to obtain, but where an abundant supply is available seedling plants may be inarched with as little expense as with the young branches of the mango.

The method has also been very successful with rare varieties of the Chinese litchi, branches of these having been united with very small seedlings of common forms of the same species.

INARCHING ROSE SEEDLINGS.

Seedlings of some of the rose groups resulting from crossing distinct varieties or otherwise take more than one season to produce flowers of maximum size to enable the breeder to judge of their merits. They take much longer to develop when budded on manetti or other stocks, because in that case a considerable time has to elapse before the growth of the seedling is strong enough to give buds and wood fit for propagation by budding or by grafting. Rose seedlings 3 to 4 weeks old, or after the first few character leaves are developed, lend themselves very readily to the seedling-inarch method of propagation. Tea and hybrid-tea seedling roses will give flowers of maximum size very quickly after the tiny seedlings are inarched to strong-growing manetti or other stocks, thereby saving much time in preliminary tests.

The operation of inarching is simplified if each seedling is pricked off into a 2-inch pot shortly after the cotyledons are developed. The

seedling should be placed as near the rim as possible (fig. 1). In two or three weeks the seedling makes sufficient growth to be removed from the pot, when a little fresh soil is held in place around the root

FIG. 1.—Rose seedlings, a cross between two varieties, four weeks after germination. Each seedlin is grown close to the rim of a 2-inch pot so as to facilitate an easy approach to the stock plants whe inarching.

FIG. 2.—The rose seedlings shown in figure 1 four weeks after germination, prepared for inarching.

by a piece of cloth about 5 inches square (fig. 2). The ball containin the roots of the seedling is secured to the stock, the stem of the seedlin being placed close to it, so that the inarch may be easily accomplishe

(fig. 3). The union is a rapid one and becomes perfect some time before the cotyledons decay.

It is well known that many seedling roses on their own roots produce flowers before the cotyledons decay, but the flowers are necessarily small and have little to indicate their eventual value. The seedling-inarch system shortens very considerably the period between germination and the production of flowers of maximum size—a material aid to the breeder in determining the value of the seedling within a few months after germination (fig. 4).

FIG. 3.—Rose seedlings, four weeks after germination, inarched to stocks of the manetti rose. During the process of uniting, the seedlings are kept in a moist and growing condition by the soil held around the union by burlap. A good union is effected in three to four weeks.

PROPAGATION OF THE FINGER LIME.

To illustrate the possibilities of the seedling-inarch method, figures 5 and 6 show a seedling of the rare *Citrus australasica* five weeks after germination inarched on a 2-year-old lemon seedling. A branch of fruit from this inarched seedling is shown in Plate I, figure 1, as it appeared two years later. The two flowers which produced these fruits were fertilized with pollen from the flowers of a small orange tree. Thirteen seedlings resulted, and one of the seedlings from this cross, two years and eight months after the seed of the female parent tree was sown, is shown in Plate I, figure 2. All these seedlings in their turn, three weeks after germination, were successfully worked on seedling citrus stocks 1 to 3 years old, and in two more years these tiny inarched-seedling crosses are expected to bloom and produce fruit.

the pots are not available they may be placed in wooden receptacles not over 4 inches square and of the same depth.

When a seedling intended for use in inarching is potted or boxed, it should not be placed in the center of the receptacle. It will be found convenient and will cause less strain both on the stem of the seedling and on that of the shoot while the union is taking place if the stem of the seedling is near the edge of the pot or box (fig. 7). The seedling so placed when subsequently prepared for inarching may be united at a point an inch or so above the soil. The plants should be potted rather firmly in hammock soil of a nature similar to that used for germinating the seeds, with a small quantity of decomposed stable manure added. A space should be left between the top of the soil and the top of the pot, say three-fourths of an inch, so that for the time being a single watering will moisten the soil thoroughly.

FIG. 6.—The same plant of the finger lime shown in figure 5 thirty days later. At this stage the top of the stock and the root of the seedling are ready to be removed.

PREPARATION OF SEEDLINGS PREVIOUS TO INARCHING.

In a few weeks some of the strongest of the seedlings will have made sufficient diameter of stem to be used as stocks for inarching. When the stem of the seedling reaches a diameter of a quarter of an inch and is fairly firm in texture (fig. 8), preparations for inarching may be commenced. The seedling is not inarched while in the pot, because even a 4-inch pot adds considerably to the weight (enough to make it impossible to tie it to the inarched branch); besides, its contents would dry out too quickly. Thick sacking cloth cut into pieces about 10 inches square is substituted for the pot. The seedling when removed from the pot is divested of that part of the soil, usually near the top, in which no roots have formed. The remaining

part of the ball is then given a protective covering of old coconut fiber or hammock soil, or if this is not convenient, chopped sphagnum moss, sand, and decomposed stable manure may be used. Part of the coconut fiber or other material is placed on the outstretched piece of sacking upon which the ball of the plant is then laid, and as the sacking is being brought up and around the ball additional soil is placed about the roots. Enough of this soil should be used to hold the moisture that is necessary while the seedling and branch are uniting. The sacking is then tied firmly with a piece of strong string and the plant is ready for working (fig. 8). This operation may be performed in about the time required to pot a seedling. Several hundred seedlings may be thus prepared at one time, and if the tree is not more than 4 or 5 feet in height every shoot may be inarched. (See fig. 9.)

FIG. 7.—Seedling mangos four months old in 4-inch pots. The stems of the stocks are about one-fourth inch in diameter. When potting, the seedlings are placed close to the rims of the pots to prevent strain on the stock and scion when inarching.

THE CONVENIENT PLACING OF MOTHER PLANTS FOR INARCHING.

Most of the work of inarching on seedlings in large pots has hitherto been done in the field. Large and unwieldy platforms have been built around trees on which to place the potted seedlings convenient for inarching with small branches.

By the new method of inarching, this trouble and expense are unnecessary. The process of inarching and caring for the seedlings during the period of uniting will require much less work than by the older methods. Plants of tested and approved varieties intended for use in propagation can be kept from growing more than 5 or 6 feet in height. There is then no necessity for wooden staging, as the prepared seedlings weigh only about 1 pound each. A seedling in a 5-inch pot weighing nearly 4 pounds needs benching to support it, but the small seedlings tied in cloth can be supported by individual stakes or by a piece of string secured to a stout branch (fig. 9). The

use of large or even moderate-sized mango trees growing in the field with several feet of stem above ground for propagating purposes is inadvisable by the method herein described, because of the inconvenience entailed both in the operation of tying on the seedlings and in supplying them with water and shade during the time of uniting.

It would be a great saving of time and work if the trees to be propagated were planted moderately close together inside a lath structure,

FIG. 8.—Seedling mango stocks prepared for inarching. The topsoil, in which there are no roots, is removed, and additional soil or coconut fiber is placed around the ball and held in place with a piece of sacking. The seedlings are then ready to be inarched. Each plant when thus prepared weighs about 1 pound.

such as is used in many parts of Florida. This would not only give protection from the sun, but with the different desirable varieties contained in an inclosure of this nature, the work of caring for them would be reduced to a minimum. The trees could be kept dwarf, the seedlings put in place without inconvenience, and a large number of

eedlings attached to branches could be watered conveniently. Every small, ripened branch could be used for inarching, and in the ase of tested and approved varieties the inarched seedlings could e planted out and kept as stock plants, to be used for inarching later n. It is entirely possible to grow a very large number of seedling-narched plants within a few years, beginning with only a single plant n a 5-inch pot.

In Florida, mango trees of tested varieties have been grown into ymmetrical specimens with many branches close to the ground, as

FIG. 9.—Branch of mango with 11 shoots inarched to seedlings. This branch is supported by a stout stake, which takes the place of the elaborate benching formerly used for the support of plants in large pots.

seen in Plate V, figure 1. When a tree of an approved variety has this habit, it is a simple matter to propagate enough young trees from it within two months to plant at least 10 acres of ground, and with a very small expenditure of money. Certainly with the material already at hand the cost per plant ready for setting out will be trifling.

MAKING THE INARCH.

First select the branchlet to be inarched, taking care that the diameter of the stem is not greater than that of the seedling stock. It should be fairly well ripened and have several healthy leaves (Pl. III, fig. 1). Make a cut in the stem, beginning at a point 2 to 3 inches from the terminal bud (Pl. III, fig. 1, *A*); in taking a slice from the stem cut into the wood not more than one-third of its diameter. The slice removed may be about 2 inches in length; any leaves which hinder this operation should first be cut off. Make a cut of similar length and depth near the base of the stem of the seedling (Pl. III, fig. 1, *B*). Bring the stock and scion neatly together, the bark meeting on both sides if possible, and tie firmly with a piece of soft string or strand of raffia (Pl. III, fig. 2). After this is done it only remains to secure the ball of the seedling to the lower part of the branch; or if the inarched branch is a short one the ball may be tied to the older wood. It will often happen that the seedling will need no further support; but when necessary a cane stake for further tying may be utilized (fig. 9), or a strong cord may be fastened to a stout stake driven into the soil in a convenient position and the inarched seedlings attached to it. Many little devices of like nature will suggest themselves to suit the peculiarities of each mother tree on which it is desired to make inarches.

WATERING SEEDLING STOCKS WHILE UNITING.

The process of uniting the seedlings to small branches of the mango trees will in no case be completed in less than four weeks; if the weather is cool it sometimes takes six weeks to effect a satisfactory union. It is very essential that the roots of the seedling be kept moist while the union is taking place. Under glass this is accomplished satisfactorily by the usual daily syringings, but out of doors, on large specimens, careful watching is absolutely necessary to prevent the seedling stocks from drying out at the roots. If the mother plants are growing within a lath structure, a syringing once or twice each day according to the weather will be all that is required. The seedlings should be often examined to ascertain their condition and supply their wants in this respect. While the stems are uniting with the branches the roots of the seedlings, if surrounded with such material as coconut fiber, will not dry out any more quickly than they would under the conditions accompanying the old method of inarching branches to large seedlings in pots.

The result of this method is to effect a perfect union. Staging for the support of large, potted seedlings is not necessary; there is absolutely no waste of material; and a much greater number of inarched plants can be grown in a given time, and much more cheaply, than by any of the older methods.

REATMENT OF THE INARCHES BEFORE SEVERING FROM THE PARENT TREE.

During the spring and summer months the unions will be in a satisfactory condition in from four to six weeks after the operation of narching is performed. But the scions must not be severed from he parent tree all at once. Unless the separation is performed radually, the check is too severe and may result in their collapse. By examining a few of the inarches about four weeks after they have been worked it will be readily ascertained if a union has taken place or if there is a likelihood of its being effected. When that stage is eached—that is, when the branch and the seedling seem fairly well united—the top part of the stock at the point immediately above the union and on the side opposite to it may be cut halfway through. A few days later the small branch united to the seedling at a point mmediately below the union should be cut to one-third of its diameter; another cut may be given a few days later and the branch, together with the top of the seedling, may be entirely severed when a safe union is effected (Pl. IV, fig. 1). It should be understood that the time required for a satisfactory union depends upon several factors, such as the weather, condition of the scion, root condition of the stock, etc., but, as thousands of successfully inarched plants have shown, there is no danger of failure if the conditions be correct.

During the past three years many persons interested in the mango from southern Florida and from places abroad have visited the propagating houses of the Bureau of Plant Industry. Simple instructions to each visitor have enabled him to attach a seedling to a mango branch with not a single resulting failure.

TREATMENT OF INARCHED PLANTS.

As soon as the inarched plants are severed from the parent tree they may be placed in a shaded frame for a few days before potting, to prevent wilting of the leaves. The atmosphere should be kept moderately moist, with the temperature not too high. The plants may then be prepared for potting by removing the string and burlap. Five-inch pots or shingle boxes 5 inches deep will be found large enough for most of the plants (Pl. IV, fig. 2). The soil will necessarily be that obtainable in the vicinity of the operations. Where loam is not available, hammock soil can be substituted, improved by adding finely chopped, old stable manure and using 1 part of this to 3 of the soil, ramming the mixture firmly around the original ball. Water is applied sparingly at first, but in sufficient quantity to keep the air moist around the plants, so as to encourage root growth. A deep frame facing north will supply the conditions necessary in this

respect. The water is best supplied to the plants by a watering can with sprinkling attachment.

As soon as the plants are established in their receptacles they should be gradually exposed to air and sunshine. Plants grown by this method (Pl. V, fig. 2), being worked immediately above the soil, can be safely sent long distances by mail. The Bureau of Plant Industry has successfully shipped inarched plants by mail to the Hawaiian Islands, and many hundreds have also been successfully sent by mail to experimenters in southern Florida.

TESTING THE NUMEROUS VARIETIES OF THE INDIAN AND OTHER MANGOS IN FLORIDA.

Although nearly a hundred varieties of the mango are now growing in Florida and elsewhere, principally as a result of the seedling-

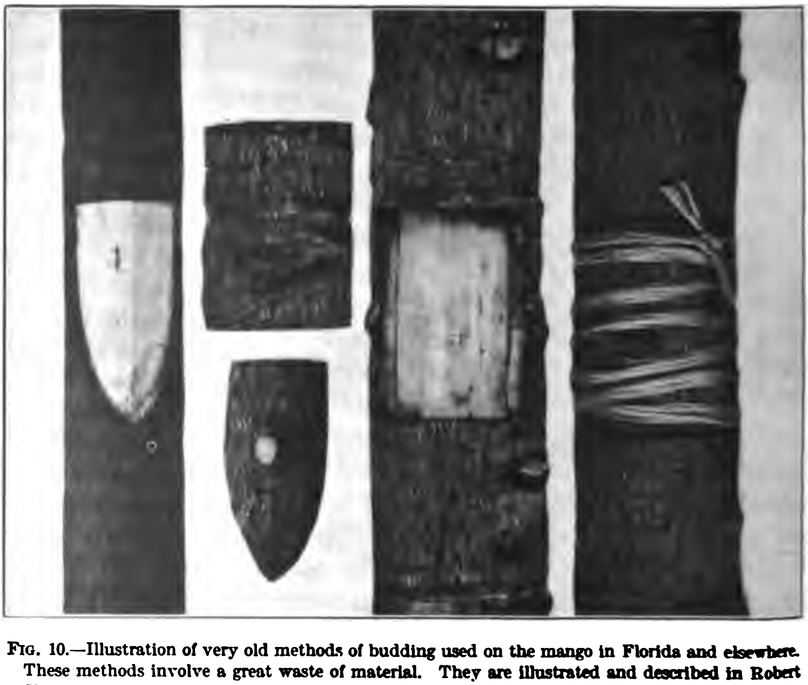

FIG. 10.—Illustration of very old methods of budding used on the mango in Florida and elsewhere. These methods involve a great waste of material. They are illustrated and described in Robert Sharrock's "History of the Propagation and Improvement of Vegetables," 1672.

inarch method, only about a dozen have fruited sufficiently to determine the quality of the fruit and its adaptability for the market. It is to be feared that many of these untested varieties are being increased irrespective of their merits. This is a mistaken policy and in many cases it may prove an expensive one. The aim of cultivators should rather be, in fruiting a variety the fruit of which is

nknown in Florida, to determine its worth before propagating it xtensively. This may be done by using small seedling-inarched lants, after they have become established in 5-inch pots, for inarchıg on the old wood of stout branches.

After removing the plant from the pot, inclose the ball with soil ept in place with a piece of sacking and strong cord. Inarch the op of the plant to the thick part of a branch of a fruiting tree. Ialf a dozen or more distinct varieties may be placed on a single ree and carefully labeled. When the unions are secured, gradually emove the branch of the tree above the union, also the original narched plant below the union, and coat the cut surfaces, especially hat of the stock, with grafting wax so as to prevent decay. If the oil of the plants to be inarched is kept moist during the process of ıniting the chances of failure are remote. The young inarched hoots will make rapid headway and will fruit much more quickly han young plants set out for testing. Two of the very old methods of budding, which are used on the mango in Florida and in other countries, are shown in figure 10.

PROPAGATING THE MANGOSTEEN.

GENERAL STATEMENT.

The mangosteen is one of the most remarkable of trees in that until lately it has defied attempts at asexual propagation. It has also the reputation of being the most difficult of all trees to grow. Most people who have sampled it pronounce it the most luscious of all tropical fruits (figs. 11 and 12).

The contention that the mangosteen is difficult to grow is abundantly proved in countries where it is cultivated and the high praise bestowed on the fruit is also well authenticated. The mangosteen is a native of the Malay Peninsula and Archipelago. It is cultivated in a small way in Ceylon, southern India, and Cochin China, and there are a few trees in the warmer islands of the West Indies, but nowhere is it cultivated to the same extent as other tropical fruit trees. It is doubtful whether more than a dozen fruiting trees can be found in the Western Hemisphere. Its requirements have probably not been understood here or elsewhere, as there is abundant evidence that it has time and again been planted in very unfriendly soils and under adverse climatic conditions. There is now little doubt that as a result of the successful experiments in its propagation in the greenhouses of the Department of Agriculture it will be possible to obtain healthy growth, especially where the mangosteen seedlings have been inarched on other species of Garcinia and also on other genera of the order to which the mangosteen belongs.

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DIFFICULTY IN GROWING THE MANGOSTEEN FROM SEEDS.

· cause of the difficulty in rearing young seedlings of the man-n· has not been fully determined. ·Several experiments car-ut from the gardener's standpoint to ascertain the cause have ced negative results. It is known that the most precarious in the life of the mangosteen tree is the seedling stage, but vith seedlings the results of careful treatment are by no means m. When a comparatively large number are given the same ·mperature, etc., all grow well until they are about 3 inches the surface of the soil. After that period, when grown on own roots, sometimes two-thirds of the number will either

FIG. 12.—Mangosteen fruits cut open, showing the white edible interior.

· in a stunted condition or the leaves subsequently developed ve a yellowish-brown color.[a]

··ems to be the experience of cultivators in Ceylon, India, and est Indies that when the leaves of a mangosteen seedling ·· a sickly appearance there is little or no hope for the future of the plant. This belief accords with the behavior of the

mangosteen fruit seldom produces more than one or two seeds. These grow ·ut, so far as we are aware, few trees have been established from them. Our ·e shows that after appearing above ground the seedling grows freely for one ·ars, but afterwards generally assumes a sickly appearance and gradually ·—Bulletin of Miscellaneous Information, Royal Botanical Garden, Trini-ıary, 1895, vol. 2, no. 1, p. 10.

first lot of seedlings in the greenhouses of the Department of Agriculture. The roots of these sickly-looking specimens when examined superficially appeared fairly healthy, but whether at the beginning the trouble is with the roots or with the leaves has not yet been determined. It is known, however, that when the seedling depends on its own roots it is impossible to get those affected seedlings to develop healthy leaves above the sickly ones. The difficulty has been repeatedly overcome (in fact in every instance) when the sickly seedling is inarched to some strong-rooted species of the same genus.

Plate VI, figure 1, shows an inarched seedling mangosteen in which the two terminal leaves did not develop; furthermore, the leaves below the terminal ones died and after inarching all the growth above the first pair of leaves gradually succumbed, but the dormant buds lower down on the seedling developed the two healthy growths shown in the illustration (Pl. VI, fig. 1, *A*). It must not be inferred from this experience that this is the only method of propagating the mangosteen—or even a desirable method, for that matter. This point will be made clear in the description of the nurse-plant method of propagation (p. 32).

CARE OF MANGOSTEEN SEEDLINGS WHILE GROWING IN POTS.

Few plants show the results of inattention on the part of the cultivator more plainly than the mangosteen. When once a plant becomes in the least sickly, there is little likelihood of its recovery on its own roots. The mangosteen does not take kindly to heavy soils; it prefers a well-drained soil containing a large proportion of decayed vegetable matter. When seedlings are removed from flats and put in pots some will die without apparent cause. An oversupply of water causing the soil to become in the least sour is certain to induce sickness much more quickly in the mangosteen than in other species of the genus. Therefore, great care is necessary in handling the plants, especially in the early stages of the seedlings.

THE ROOT SYSTEM OF THE MANGOSTEEN COMPARED WITH OTHER SPECIES OF GARCINIA.

Unfortunately the mangosteen is not a strong-rooting plant, especially during the first year or two after germination. This peculiarity renders it particularly sensitive to dry weather and may account in part for the many failures to grow it successfully. Nearly all the other species of the genus have strong and abundant roots, even in the seedling stages. It therefore seems likely that the mangosteen will thrive better and under more widely varying soil and atmospheric conditions if the young plant is inarched to some species of the genus which has a good root system.

PROPAGATION BY THE ORDINARY METHOD OF INARCHING.

When the ordinary method of grafting is employed or when mature anches of the mangosteen are inarched to stocks of some of the ge-leaved species of Garcinia, unions are obtained which appear ite firm and evidently successful, but the differences in texture tween the woods of stock and scion are too great for good unions be effected. The lateral shoots or small branches of young trees the mangosteen 3 to 4 feet in height have been tried repeatedly; it the wood of the mangosteen growths does not attain that requi-;e hard consistency which we get in seedling Garcinias of other ecies, varying in size from a few inches to 1½ feet in height. The ood of these seedlings is comparatively hard and gives a rapid and tisfactory callus; the branches of larger mangosteen plants on the her hand are green and comparatively soft, and the inarches, ter being gradually severed from the parent mangosteens, look irly promising for a day or two, but notwithstanding the best of re they droop and shrivel. Further experiments with shoots of rger mangosteen plants are now in progress to ascertain the result f delaying the severance of the mangosteen shoots from the mother ree, ranging from a period of six weeks to one of three to six months. he sound appearance of some of the unions indicates that this ethod may be successful.

CONDITION OF THE WOOD OF SEEDLING MANGOSTEENS.

The texture of the stems of the seedling mangosteens 3 to 4 months ld is firmer than that of lateral branches of seedlings 3 to 4 feet igh, and at the earlier stage is admirably adapted for inarching; n fact, when united to a strong-growing plant of any of the larger eaved species of Garcinia, the union is rapid and very satisfactory. Seedlings of the mangosteen with stems averaging one-sixth of an nch in diameter at the time of inarching have increased within three months to half an inch in diameter.

STOCK PLANTS FOR THE MANGOSTEEN.

The mangosteen (*Garcinia mangostana*) belongs to the natural family Guttiferæ. The genus Garcinia is a large one, the Index Kewensis listing 228 species. Of these species about 20 have been tried in the inarching experiments; and while the mangosteen unites with all of them, only a few can be recommended as promising stock plants. Two other genera of the same family, Calophyllum and Platonia, have been tried. Two species of Calophyllum, *C. calaba* and *C. inophyllum*, are not satisfactory because the union between these and the mangosteen is imperfect. This is partly because the stems of the Calophyllums are softer than those of the

seedling mangosteen and partly because the growth made by the former as they become older is much more rapid. *Platonia insignis* (Pl. VI, fig. 2), on the other hand, so far as the experimental work has progressed, is a very promising stock from one to three years after germination, and if it will grow under the conditions suitable for the mangosteen, it may turn out to be the best stock of all those tried. The most promising species of Garcinia for use as stock plants for the mangosteen are *G. tinctoria* (fig. 13), *G. morella*, and *G.*

FIG. 13.—Mangosteen seedling inarched on *Garcinia tinctoria* with foliage of stock plant opposite and below the union. Height of seedling at time of inarching, about 10 inches.

livingstonei, in the order named, the last a native of Portuguese East Africa. The two first named are from the Malay Peninsula.

The list of species of Garcinia experimented with is as follows: *G. cornea*, *G. hanburyi*, *G. morella*, *G. tinctoria*, and *G. spicata*, from the Malay Peninsula; *G. binucao*, *G. cowa*, and *G. indica*, from India; *G. livingstonei*, from Portugese East Africa; *G. speciosa*, from Burma; *G. loureiri* and *G. sizygiifolia*, from Borneo; and *G. fusca*,

om Siam. It is quite possible that several other species of Garnia may be even more valuable as stock plants, and also that some pecies of the related genera may prove desirable, but other material an that mentioned has not been available in the work. All the romising species ought to be tried whenever there is an opportunity. ome species of Garcinia lately found in the Philippine Islands would eem to be promising mangosteen stocks, especially those said to row under widely varying conditions.

GROWING SEEDLING STOCKS.

None of the species of Garcinia used as stocks are difficult to raise rom seeds, provided they are fresh. They are easiest to germinate when sown in soil composed largely of partially decomposed leaves nixed with a little loam and rough-grained sand. They should be potted as soon as the first leaves are well developed. All the Garcinias with the exception of *G. mangostana* have magnificent root systems and they thrive under ordinary treatment in so far as soil watering and a considerable range of temperature are concerned.

It is an important point to have the stock plants in an active stage of growth when the union is in progress, though the seedling mangosteens may be inarched while apparently dormant. Although the unions when both stock and scion are in a resting stage are fairly satisfactory, the difference in growth is easily observable when the stock plants are in active growth. To secure this active growth the stocks should be allowed to become dormant; then, when they are given larger pots, good drainage, and soil composed of rotted leaves, at least one-half, and the rest fibrous loam containing a little rough-grained sand, together with some rough charcoal and crushed bone, they will under high temperature respond with vigorous growth. When inarched in this condition the union is always satisfactory.

All plants used as stocks have been from one to three years old. Within that period the age of the stocks seems to make little difference, especially when used as nurse stocks. Mangosteen seedlings seven months old united on nurse stocks of 3-year-old *Garcinia tinctoria* made very fine unions (Pl. VII), and within six months after the union some of the mangosteen stems were almost as thick as those of the stocks.

PREPARING SEEDLINGS FOR INARCHING.

The propagation of seedling mangosteens for inarching on the stems of seedling stocks of other species of Garcinia (fig. 13) does not differ materially from that operation as described for seedlings of the mango (p. 15). The most important difference to be observed

is that the roots of the mangosteen need to be kept alive only long enough to give partial support to the seedling while the union is taking place. In the inarched mango the roots of the seedling are very carefully tended because they are to become the roots of the future mango tree. To insure sufficient moisture, place around the ball of the seedling fresh sphagnum moss mixed with twice the quantity of partly decayed leaves. Keep this material in position around the roots of the seedling with a piece of cloth which will absorb water readily. The seedling may be supported with a piece of $\frac{1}{8}$-inch galvanized-iron wire while the union is taking place.

MAKING THE INARCH.

Place the stem of the seedling mangosteen close to that part of the stem of the stock where it is desired to make the union, then tie the root of the seedling inclosed in a piece of sacking to the stem of the stock plant with a strand of raffia. After making the tie, and before cutting the ends of the strand of raffia, put in the wire support and make secure with raffia. Cut a slice from the stem of the stock, going into the stem about one-third of its diameter. The length of the slice is regulated by the length of available stem in the seedling; 2 inches is desirable, but less will suffice. Next remove a piece of the stem of the seedling exactly opposite the cut in the stock, exercising extreme care in making one side of the cut on the scion fit evenly with one side of the cut on the stock. Pay no attention to the other edges of stock and scion, but bind firmly together and the operation is complete. If the inarching is performed in summer, and this seems the best time, make a puddle of adhesive clay, mixing it with some raw cotton which has been cut up fine with a pair of shears; apply this around the parts to be united and allow it to dry. The clay serves two purposes—it excludes air and it absorbs all the sap exuded from the cut portions. The raw cotton prevents the puddled clay from disintegrating while the union is taking place.

It is well that the point of union should be so chosen that a few leaves of the stock plant may be left growing below the union (fig. 13) after the top of the stock and the roots of the seedling have been removed. If the union is near the base of the stock and below the foliage the subsequent growth made by the inarched seedling mangosteen after being separated from its roots is not so rapid nor so robust as it is when placed farther up the stem and above a few of the leaves. When mangosteen seedlings are inarched on nurse stocks the conditions are different, and the union is made as low on the stock as possible (Pl. VI, fig. 2, *C*).

[R]EMOVING THE TOPS OF THE STOCKS AND THE ROOTS OF SEEDLING MANGOSTEENS AFTER A UNION HAS BEEN EFFECTED.

After the seedling mangosteens have become united with the stock [p]lants the tops of the stocks should be gradually severed above the [u]nion. A notch may be made in the stem of the stock immediately [a]bove the union and on the side of the stem opposite to it. Ten days [a]fterwards the top may be removed altogether.

When seedling mangosteens are inarched with the intention of [r]emoving the roots after the union is perfect, the soil around the roots, [h]eld in position by the piece of cloth, should be allowed only a small [q]uantity of water for a period of about two weeks after the tops of [t]he stocks have been removed, then the stem of the mangosteen seed[l]ing may be gradually severed immediately below the union. Any [l]eaves on the stem of the stock plant below the top of the united parts [(]fig. 13) may be allowed to remain, as they are helpful in keeping the [i]narched seedling in a healthy condition till the time arrives when it will make large leaves of its own. But in the nurse-plant method it does not seem necessary to allow any of the leaves to remain on the stock.

INARCHED MANGOSTEEN SEEDLINGS REESTABLISHING THEIR OWN ROOT SYSTEMS.

During the progress of the experiments in inarching the mangosteen several of the inarched plants exhibited a peculiar characteristic which up to that time had not been noticed in any other inarched plant. About eighteen months after 1-year-old mangosteen seedlings were apparently united to *Garcinia tinctoria*, as well as to other species, and long after the root and part of the stem of the mangosteen seedling, together with the top of the stock, had been severed and the mangosteen had made splendid growth, as evidenced by large, well-formed, and deep-green leaves, each suddenly developed a very thick aerial root at the base of the inarched stem of the mangosteen (Pl. VIII, fig. 2). This root became elongated and pierced the soil several inches below the point at which the roots first appeared, apparently making very rapid progress after reaching the soil. About two months afterwards the extra rapid growth of the new leaves was pronounced. In one or two instances the stock plants on which the mangosteens were inarched began to decay; the dissolution was rapid, and in a few months from the appearance of the aerial roots the rebellious mangosteens were again on their own roots, looking strong and healthy (Pl. VIII, fig. 1).

The behavior of the inarched seedlings in reestablishing their own root systems strongly suggests noncongeniality of the scion to the

stock; but that this is not true is proved by the behavior of those mangosteens propagated by the nurse-plant system. Moreover, it has been found that the stems of seedlings when inarched at a point 2 or 3 inches above the first pair of leaves on the stocks, as seen in figure 13, evidently make permanent unions; at least, there has been no attempt on the part of the scions to produce roots, and the stems of the stocks have increased considerably in girth since the unions took place. As further evidence that the formation of roots at the base of the inarched branch is not due to noncongeniality of stock to scion it may be mentioned that the bases of the inarched branches of litchi when inarched on seedlings of the same species form roots very freely. Especially when the branch is severed an inch or two from the lower part of the union, and the cut surface touches the soil, roots are always formed abundantly. It has been possible in numerous instances, after these roots have made considerable headway, to obtain a second plant as a result of this characteristic by severing the stem after rooting at a point as near the base of the inarched part as possible.

During the early part of 1909 the idea suggested itself that this peculiar feature in the behavior of inarched mangosteen plants described above might be used to bring the seedlings through the earlier and crucial stages of their existence. So far as our work has gone the results are exceedingly satisfactory, and the new method may be termed the nurse-plant system of propagation.

THE NURSE-PLANT SYSTEM OF PROPAGATING THE MANGOSTEEN.

About thirty seedlings of the mangosteen, averaging 4 inches in height, were available for taking advantage of the lesson taught by the behavior of the inarched plants described above. All of these seedlings were beginning to show in their foliage signs of sickness. They were carefully removed from the 3-inch pots in which they had been growing, the soil was washed from the roots in tepid water, and each seedling was planted in a 6-inch pot containing a healthy 2-year-old plant of *Garcinia tinctoria*. Each mangosteen was planted as close to the nurse plant as possible without destroying its roots, so that inarching could be easily performed after the mangosteen showed signs of recovering from any slight setback resulting from its removal. The plants were placed in a humid atmosphere with the temperature ranging from 70° at night to 90° F. during the day. Three weeks after the seedlings were placed in the pots containing their prospective stocks they showed a slight improvement. They were then carefully inarched, and within six weeks the improved appearance of all the seedlings indicated that successful unions had taken place (fig. 14). The tops of the stock plants were then removed. The subsequent progress made by the mangosteens on nurse stocks

as been in many instances greater than that made by seedlings narched by the ordinary method (Pl. VII). Several of these mangosteens worked by the nurse-plant method have been sent to the Canal Zone and are reported to be doing well. The remaining ones till in the greenhouse continue to make good growth, but the stems of the stock plants do not show as much increase in diameter as do hose of the mangosteens attached to them (fig. 14).

In some instances the roots of the nurse plants show no appreciable cessation of growth after the tops of the plants have been removed. One would expect that in such event the roots of the inarched mangosteen seedlings would not be well developed, but as a matter of fact they are much superior to those of an uninarched seedling of the same age (Pl. VII), proving that as a result of the union the mangosteen is nursed along during the critical period of its existence in a

FIG. 14.—Group of mangosteen seedlings inarched by the nurse-plant method. The tops of the nurse plants have been removed.

most satisfactory way. This undoubtedly indicates that the mangosteen needs treatment of this nature to bring it through the early seedling stages, because the roots of the uninarched seedlings, especially within a year after germinating, are never robust, and too much or too little water produces bad effects. Those plants, however, which were inarched on other species of Garcinia by the seedling-inarch method seem to thrive well when subjected to the treatment usually accorded inarched mangos.

Although our experiments in inarching the mangosteen on nurse plants have turned out very satisfactorily, not a plant being lost, the method first used has been improved considerably, so that there is now less danger from careless work. The nurse plants of *Garcinia tinctoria* should be grown in small-sized pots, not larger

than 4 inches, previous to placing them in the 6-inch size. When getting their final shift the ball should be manipulated so that the stem of the seedling will be a little to one side so as to make room for an empty 3-inch pot to be placed in the soil beside the stock plant (Pl. VI, fig. 2, *A*). When the stock plant is established in the soil, after perhaps three or four weeks, that is, when the new roots have had time to develop, the empty 3-inch pot is removed (Pl. VI, fig. 1, *B*) and the root of a mangosteen taken from a pot of the same dimensions is placed in the empty space and the soil carefully but firmly rammed around it. Generous treatment will result in further development of the root action of both mangosteen and nurse stock. They are then inarched (Pl. VI, fig. 1, *C*), and when the union is satisfactory, which will be in about five weeks, the top part of the stock above the inarch may be gradually removed. The roots of both nurse plant and scion are left undisturbed because, if the stock dies, the root system of the seedling mangosteen will probably have become strong enough to sustain the plant by reason of the assistance given to it by the nurse plant during its precarious stage; and if, on the other hand, the roots of the seedling succumb, it probably will be due to the fact that the stock is supplying enough root action for the mangosteen.

FUTURE STAGES OF GROWTH.

It should be distinctly understood that certainty of success with either method, in so far as it relates to the future stages of growth of the mangosteen, is by no means guaranteed when the plants are put in place in the open. All that it is intended to claim is that the method is a promising one on account of the rapid progress made by the seedlings after the union takes place. The seedlings which have been inarched have not as yet had time to make sufficient progress to demonstrate that they will grow rapidly on the stocks used; but it has been thought best to make public the discovery of this method as soon as possible, in order that experimenters may try it with a large number of different stocks. The mangosteen, however, is well known to be a rebellious subject; and beyond the union of its seedlings with older stocks of different species nothing has been accomplished.

PACKING SEEDS FOR SHIPMENT.

It has been found that mangosteen seeds received in numerous shipments from various parts of tropical Asia do not retain their vitality for any considerable length of time, probably on account of unsuitable packing material or of improper packing. Most of the shipments have arrived without a trace of life in the seeds, a

condition due to the packing material in the tin mailing tubes being too wet. Sometimes the seeds arrived in dampened moss and sawdust, mixed in equal parts. Other shipments were received packed in each of these materials, sometimes wet, at other times dry; but as yet we have never received a successful shipment when these materials were used, whether wet or dry. The best shipment came from Ceylon a few years ago, packed in comparatively dry, powdered charcoal. From that particular shipment nearly every seed sprouted. The charcoal when weighed immediately after the seeds were removed and again when sundried, showed a difference of less than half an ounce to the pound. It sometimes happens that the tin mailing tubes, frequently less than 2 inches in diameter, are so placed en route that they are subjected to high temperatures and the seeds are thus injured.

PRELIMINARY TREATMENT AND SOWING OF THE SEEDS.

The seeds should be carefully looked after the moment they arrive. If any of them have made an effort to germinate en route while still in the charcoal, owing to some of the fleshy part of the fruit adhering to them when they were shipped, they should be handled with very great care, as the soft protruding parts are very susceptible to injury. Washing them in tepid water will partly remove some of the deleterious matter surrounding them. Before they become dry they should be dusted with powdered charcoal and immediately planted one at a time in a flat of leaf soil made quite firm. The germinating medium may be prepared beforehand when a shipment of seeds is expected. It should not be gathered promiscuously from the woods, as it is then liable to contain deleterious matter. Beech leaves about a year old, chopped very fine, with a small quantity of rough-grained sand and a little charcoal added, will give a very satisfactory germinating medium. When the seeds have begun to sprout en route, they should not be pressed into the material; but each one should be arranged with the sprouted part occupying a slight depression on the surface of the soil and covered with half an inch of the material. The leaf soil should be placed in a wooden flat and the top of the box covered with panes of glass, so that a humid atmosphere may be constantly maintained. The temperature of the greenhouse should range from 75° F. at night to much higher in the daytime and the seed box should be protected from direct sunlight.

The seedlings will thrive in the seed flat until they are about 2½ inches above the surface. They may then be potted off singly in 2½-inch or 3-inch pots, with good drainage. In potting, material should be used similar to that recommended for germination, with a very

small quantity of mellow loam added. Coconut fiber or even thoroughly rotted wood may be mixed with it, care being taken that it is free from deleterious fungi. If leaf soil is not available, coconut fiber is very good, but great care is necessary in watering, as the fiber holds water like a sponge. Thus a 5-inch pot will hold 6 ounces of dry fiber when firmly pressed down, but twenty-four hours after being saturated the fiber will weigh 19 ounces. It not only holds more water than most other substances, but it holds it longer, and it is this peculiarity which makes it one of the best media for germinating purposes, that is, provided the attendant is able to judge accurately of its water content.

FIG. 15.—Group of inarched litchi plants; also seedling litchi stocks prepared for inarching.

PROPAGATING VARIETIES OF LITCHI BY THE SEEDLING-INARCH METHOD.

Plants of one of the finer varieties of litchi (*Litchi chinensis*) were obtained from China two years ago. They are said to be propagated in that country partly by layering and partly by notching large branches, and covering the wounds with a quantity of soil kept moist. When roots are at length produced, the branches are removed from the tree, trimmed, and put in receptacles until time for planting; but during the period of propagation the percentage of loss is said to be large. The propagation of these plants by the seedling-inarch method has been very successful (fig. 15). The Chinese, or litchi, nuts, as they are called (Pl. IX), offered for sale in the fruit stores of this country are dried previous to their importation and therefore are useless for the purpose of raising young plants. The Office of Foreign Seed and Plant Introduction of the Bureau of Plant Industry obtained a small consignment of untreated litchi seeds from China

bout eighteen months ago, all of which germinated. The plants ıus obtained proved to be the best stocks to use. Young branches f the improved variety of the litchi were inarched on these seed-ngs, every one making a very successful union. They were sub-equently distributed. Many hundreds of plants could be propa-;ated annually from the plants of this variety of the litchi now in he greenhouse if seedling litchi stocks were available for inarching. The next best stock is the longan (*Euphoria longan*), but while the unions are fairly successful on this species, they are slower than with the litchi stocks.

The litchi as a fruit-producing plant is at its best in China when grown in comparatively wet ground and in soil consisting largely of decomposed vegetable matter. It probably would succeed admirably in the Everglades of Florida in places where there is little likelihood of exposure to a temperature lower than 30° F. In California the tree does not look happy, but all of those recently seen by the writer were in dry, loamy soil. The Canal Zone and Porto Rico will probably prove congenial homes for this fruit tree. The fruits sent to the United States are not of the best varieties, being small, seldom more than an inch in diameter. The finer varieties are said to bear much larger fruit.

The method of propagation in its essential features is like that described for the mango (p. 14). The seedlings to be used as stocks are taken from 3-inch pots, the soil on the upper part of the ball removed, and a large handful of coconut fiber secured around the roots by wrapping in a piece of sacking about 8 inches square. These seedling stocks are fastened to the stout branches of the parent litchi or to stakes set in the soil of the pot. The branchlets are then inarched to the seedlings and tied with raffia, and the parts to be united are covered with clay. During the few weeks occupied in uniting, the roots of the seedlings make rapid headway in the coconut fiber. The unions are invariably good when seedlings of the same species are used. If the compound leaves on the scion are large it is advisable to trim them back slightly before severing the inarch from the parent tree. After severing, the inarched plants may be potted and placed in a close frame in the greenhouse, or they may be put in shallow boxes and the roots covered with coconut fiber, the atmosphere being kept moist. The sacking should not be removed, because, when the scions have united, the white roots of the seedlings will be found to have pierced the covering, so that to remove this sacking would necessarily injure the roots. The balls should be put in 5-inch or 6-inch pots, as may be necessary; the soil should consist mainly of decomposed leaves.

It is a peculiarity of the litchi that it makes several flushes or growths in a season; therefore, material for propagation is abundant

even in a small tree. Seedling stocks have been used when the stems were not over one-eighth of an inch in diameter and from that to one-fourth of an inch, the latter thickness giving the best results.

PROPAGATING THE RAMBUTAN.

The rambutan (*Nephelium lappaceum*), said by some of the inhabitants of Java and elsewhere to produce a fruit even more delicious than that of the mangosteen, is amenable to rapid propagation if the young shoots are united to seedling stocks of the longan (*Euphoria longan*). It is thought that the Canal Zone will supply the necessary conditions for the successful cultivation of this tree. It is said that there are several varieties, and if it is possible to import vegetatively propagated plants of these varieties successfully, as was done with the litchi, their rapid multiplication in this country will be assured.

SUMMARY.

It will be observed from the foregoing descriptions of the improved methods of propagating the mango, the mangosteen, and the litchi that practically the same method is employed with each; the uniting of a comparatively young seedling with a shoot of an approved variety of mango; the uniting of mangosteen seedlings with different species of the genus to which the mangosteen belongs, and even with species of different genera of the same family; and the uniting of shoots of approved varieties of litchi with seedling stocks or with seedlings of other species of the same genus.

Seedlings not more than a few months old are always used. The mango and litchi seedlings are used as stocks only, but the mangosteen seedlings are used as scions.

The operation with each kind of plant is a decided success. The method is so simple that it can be used by a person having no previous experience in the propagation of plants. It saves much of the time necessarily spent with the older methods. The worked plants are healthier and the operation is many times cheaper than the older methods.

PLATES.

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DESCRIPTION OF PLATES.

PLATE I. Fig. 1.—Australian finger lime (*Citrus australasica*) inarched on lemon stock when a 5-weeks-old seedling; shown in text figures 5 and 6. In bearing only two years after the germination of the seed. The fruits are the result of cross-pollination with the so-called Panama orange. Fig. 2.—Crossed seedling of Australian finger lime and the Panama orange, grown from seed of fruit shown in figure 1. One of 13 seedlings showing hybrid characters in increased size of leaves and slightly winged and elongated petioles. This seedling was inarched three weeks after germination to a 2-year-old lemon stock. The top of the stock plant has been removed and the root of the seedling is ready to be severed. Time taken to form union, three weeks.

PLATE II.—Germination of mango. Seed with 8 sprouts, six weeks after planting. The two strongest sprouts should be selected for stocks and potted, the others discarded.

PLATE III. Fig. 1.—Mango seedling stock fastened to branch of tree of an approved variety, ready for inarching. The cuts in scion and stock are shown at *A* and *B*. Fig. 2.—Mango seedling with scion of approved variety tied in position. If conditions are favorable, a union will be effected in about thirty days.

PLATE IV. Fig. 1.—Inarched mango. The top of the seedling stock above the union has been gradually removed, and the shoot of the approved variety has also been gradually severed from the parent tree. Fig. 2.—Inarched mango in 5-inch pot. The sacking inclosing the roots is carefully removed unless the roots show outside the sacking, in which case the ball is placed in a 5-inch pot and fresh soil rammed firmly between the ball and side of the pot.

PLATE V. Fig. 1.—Mulgoba mango growing at Mangonia, Fla. This is the original tree of this variety introduced into Florida by the Department of Agriculture in 1889. This tree having numerous branches near the ground shows how easy it would be to inarch a very large number of shoots by the method here described. Fig. 2.—Bench of newly inarched mangos. After potting they are shaded from the sun and the atmosphere kept humid for a few days.

PLATE VI. Fig. 1.—Sickly mangosteen restored to health by inarching on *Garcinia tinctoria*. The original stem of the seedling, which had lost its upper leaves before being inarched, is shown at *A*. After the union took place both of the lateral shoots seen in the illustration developed and the top of the seedling died. The plant afterwards made fine growth. Fig. 2.—Inarching the mangosteen by the nurse-plant method, showing empty 3-inch pot inserted in soil when potting. Empty pot removed, leaving space for root of seedling from a 3-inch pot. Root of seedling mangosteen from 3-inch pot inserted in space provided for it and inarched to nurse stock plant of *Platonia insignis*.

PLATE VII. The nurse-plant system of propagating the mangosteen. The seedling was inarched to a plant of *Garcinia tinctoria* when the former was about 3 inches high and in a sickly condition. The roots of both stock and scion are developing satisfactorily. The plant represented was taken from a 6-inch pot.

PLATE VIII. Fig. 1.—Inarched mangosteen reestablishing its own root system. *A*, scar showing where it was inarched to a seedling of *Garcinia tinctoria*; *B*, point showing where the new root formed some time after the union took place previous to the rejection of the stock. Fig. 2.—Mangosteen developing a large root after it had been inarched to another species of Garcinia. The stock in this instance shows no signs of decay.

PLATE IX. Fruiting branch of litchi (*Litchi chinensis*). Two-thirds natural size.

FIG. 1.—CITRUS AUSTRALASICA, BEARING FRUIT TWO YEARS AFTER THE GERMINATION OF THE SEED.

FIG. 2.—CITRUS AUSTRALASICA × C. MITIS, GROWN FROM FRUIT SHOWN IN FIGURE 1.

MANGO SEED WITH EIGHT SPROUTS.

(One-half natural size.)

FIG. 1.—MANGO SEEDLING ATTACHED TO TREE, SHOWING CUTS IN STEMS OF SCION AND SEEDLING.

FIG. 2.—MANGO SEEDLING AND SCION IN PLACE.

FIG. 1.—INARCHED MANGO AFTER BEING SEVERED FROM PARENT TREE.

FIG. 2.—NEWLY INARCHED MANGO IN POT.

FIG. 1.—MULGOBA MANGO GROWING AT MANGONIA, FLA.

FIG. 2.—BENCH OF NEWLY INARCHED MANGOS.

FIG. 1.—SICKLY MANGOSTEEN RESTORED TO HEALTH BY INARCHING.

FIG. 2.—INARCHING THE MANGOSTEEN BY THE NURSE-PLANT METHOD.

MANGOSTEEN SEEDLING INARCHED TO GARCINIA TINCTORIA, NURSE PLANT.

(Much reduced.)

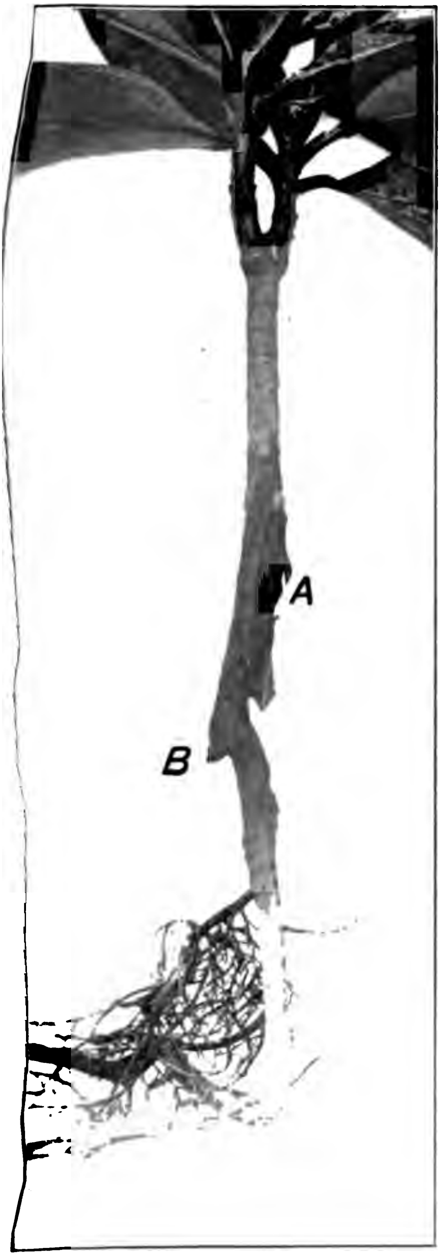

FIG. 1.—INARCHED MANGOSTEEN REESTABLISHING ITS OWN ROOT SYSTEM.

FIG. 2.—MANGOSTEEN DEVELOPING ROOT AFTER INARCHING.

FRUITING BRANCH OF THE LITCHI (LITCHI CHINENSIS).

(Two-thirds natural size.)

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 203.

B. T. GALLOWAY, *Chief of Bureau.*

THE IMPORTANCE AND IMPROVEMENT OF THE GRAIN SORGHUMS.

BY

CARLETON R. BALL,

AGRONOMIST IN CHARGE OF GRAIN-SORGHUM INVESTIGATIONS.

ISSUED JANUARY 20, 1911.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1911.

BUREAU OF PLANT INDUSTRY.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., September 21, 1910.

Sir: I have the honor to transmit herewith a paper entitled "The mportance and Improvement of the Grain Sorghums," by Mr. 'arleton R. Ball, Agronomist in Charge of Grain-Sorghum Investigaions, and recommend its publication as Bulletin No. 203 of the eries of this Bureau. This paper presents the best known methods f improving these crops, both at experimental stations and on the arms where they are grown. The value of the grain for feeding tock and poultry is shown, and the acreage, yields, and acre values of hese crops are recorded so far as data are available. The facts preented are the result of four years of work in the Office of Grain nvestigations.

The areas devoted to grain sorghums in the dry regions of the outhwest are rapidly increasing. Their earliness, productive ower, and strong drought resistance especially adapt them to semirid conditions. The importance of these crops, however, is even reater than can be measured in terms of increased acreage. They re not only staple crops, but in many places they are the chief ependence of the new settler, and their success or failure determines is ability to become established.

Respectfully,

Wm. A. Taylor,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS

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THE GRAIN-SORGHUM BELT.

BOUNDARIES.

The grain sorghums are most largely grown in the southern half of the Great Plains region (fig. 1).

Broadly speaking, this region includes the plain lying between the ninety-eighth meridian of longitude and the Rocky Mountains. The

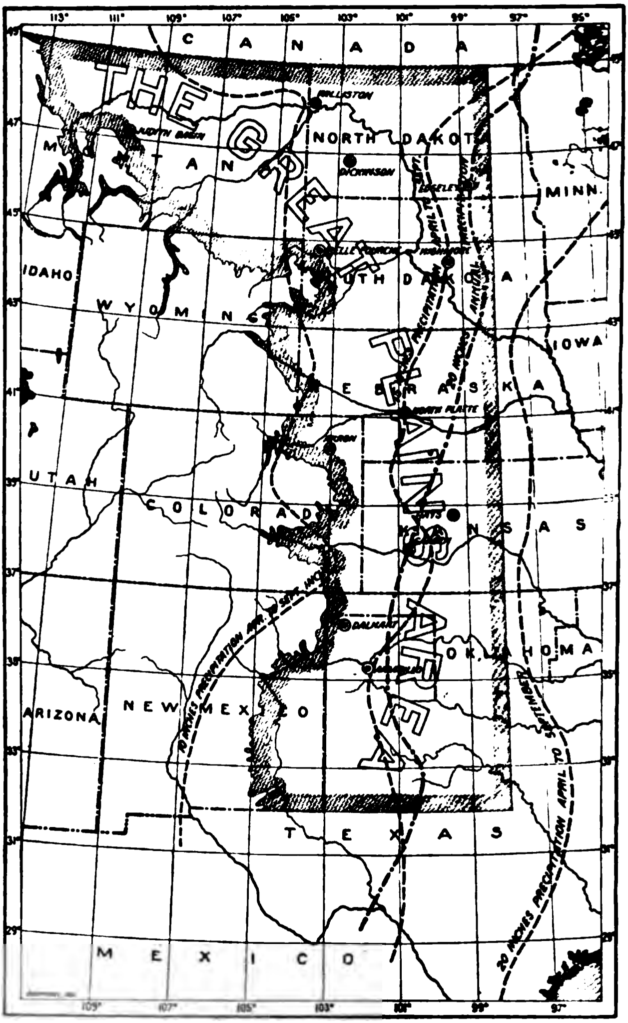

FIG. 1.—Map of the Great Plains area, showing the annual and the seasonal rainfall.

southern half of it may be said to include the area between the northern boundary of Kansas and the Mexican border, although the extreme southern part of western Texas does not belong to the Great Plains proper. The area thus bounded takes in the western half of

ansas, the western third of Oklahoma, the western half of Texas, nd all those portions of Colorado and New Mexico that lie east of the ocky Mountains. In round numbers the area is 400 miles wide and ,000 miles long. So important are these crops in this area that it ay well be called the "grain-sorghum belt."

SURFACE FEATURES.

The surface of the area just outlined is in general a gently rolling lain, sloping steadily eastward from an elevation of 4,000 to 5,000 eet at the base of the Rocky Mountains to an average elevation of ,000 to 1,500 feet at the ninety-eighth meridian. The highest point n these plains is not at the base of the mountains, but some distance ast of them, in Elbert and El Paso counties, Colorado, where the ltitude increases to nearly or quite 6,500 feet. While the main lope is toward the east, there is also a secondary slope to the north nd south from this high area in Colorado. Looked at from above he surface of the whole Great Plains region may be compared in utline to half of an inverted saucer, the rim lying toward the east.

SOILS AND PLANT COVERING.

The soils of this region vary from the dark clays of the central Panandle and the red clays of western Oklahoma, through sandy loams ound in various parts of the region to very sandy soils, such as characterize the sand-hill country of Kansas and Colorado.

The plant covering of the loams and clays is mostly a dense sod of buffalo grass and blue grama mixed. In southwest Texas the buffalo grass gives place to the curly mesquite, or running mesquite, as it is often called (*Hilaria cenchroides*). On the more sandy soils taller and more bunchy grasses prevail, such as the bluestems (*Andropogon provincialis*, *A. scoparius*, *A. saccharoides*, etc.). In much of western Texas the plains have been largely covered by a more or less dense growth of the mesquite tree (Prosopis). In southern Texas this becomes a large tree, but as it ascends to the higher plains its size diminishes until in the upper Panhandle it is only a low shrub or bush.

CLIMATE.

What really separates the so-called Great Plains region from the country lying immediately east of it is, primarily, not differences in either elevation or soil, but the lower rainfall and higher evaporation of moisture. The average annual rainfall for the grain-sorghum belt, as defined above, is about 20 inches, of which more than half comes in the months of April to September, inclusive. (See fig. 1.) The summer temperature is fairly high, and this, with the steady breeze which prevails over much of this area, makes evaporation rapid and continuous.

All crops to be suitable for use in this area must have the ability either to withstand or to escape drought in one way or another. Dry, hot winds occasionally occur in some parts of the region, often quickly and completely destroying all tender vegetation. At the higher elevations and in the northern part generally the season is comparatively short and early varieties must be used, because late spring frosts occur and the first frosts of autumn come rather early.

AGRICULTURAL DEVELOPMENT.

The process of dividing the great cattle ranges and selling them for farms is going on steadily. Wherever government land remains homesteads are being taken up. In the past few years the settlement of this dry country has been rapid. Rapid settlement may be desirable; it is much more important, however, that it be permanent. This has not always been the case.

No one may say with certainty just what the future of this southern Great Plains region is to be. It gives promise of becoming a second great feeding belt, similar to the corn belt. Nothing better could be wished than that it should grow live stock and the crops to feed them. Under such a system of farming this area would produce much more live stock than it ever did or could under the ranch and range system. If it should raise a money crop in addition, so much the better. This might be cotton in the southern part, winter wheat in the central, and spring wheat in the northern part, with broom corn and other minor crops in different parts. The area is admirably adapted to the growing of both the stock and the necessary feeding crops. These crops will be corn in the regions of lower altitude and greater rainfall and grain sorghums in the higher and drier parts.

IMPORTANCE OF THE GRAIN-SORGHUM CROP.

The following paragraphs cover briefly the history of the grain sorghums in the United States, the general conditions to which they are adapted, and some statistics of their acreage, yield, and value.

HISTORY OF THE VARIETIES.

It is only thirty-five years since the first grain sorghums (fig. 2) were introduced into the United States. It is only twenty years since any of them have become crops of recognized importance. Although grain-producing varieties had probably been introduced from time to time since early colonial days none had persisted in cultivation.

The first permanent introductions were the two durras, Brown durra and White durra, which reached California in 1874 under the

names, "Brown Egyptian corn" and "White Egyptian corn." The white variety had two periods of popularity in the Great Plains area, first, in the early eighties, under the name "Rice corn," and again, ten years later, under the name "Jerusalem corn." Both varieties are still grown, but only to a limited extent owing to their shattering habit.

Two varieties of kafir, the White and the Red, were brought from South Africa in 1876. They did not get into general cultivation here until about 1890, fourteen years later. The Blackhull kafir appeared

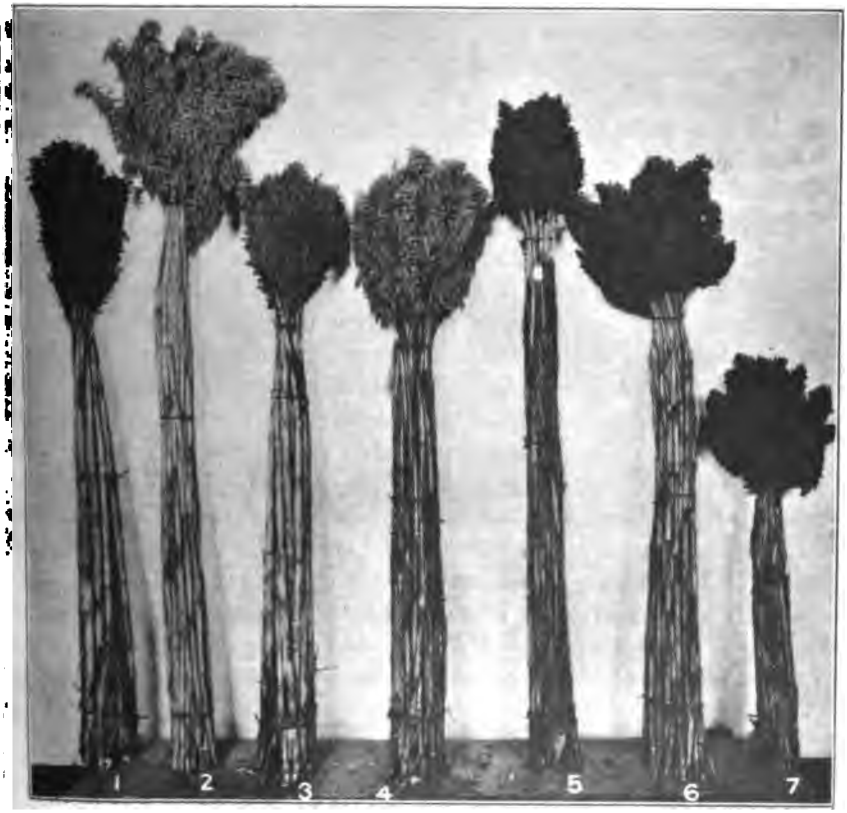

FIG. 2.—Sheaves of improved grain sorghums: 1, Red kafir; 2, shallu; 3, Blackhull kafir; 4, White durra; 5, Brown kowliang; 6, milo; 7, Dwarf milo.

soon after, but whether it was a part of the original importation or was a later introduction will probably never be known. The original White kafir is rarely found in cultivation to-day, but the Red and the Blackhull are important crops.

Milo was first introduced into South Carolina or Georgia about the year 1885, but did not come into general notice until about 1890, when it had become a staple crop in parts of western Texas.

The kowliangs have been coming from China and Manchuria since 1901. Most of them have required considerable selection to make them suitable for use as grain crops. None of them has been long enough in the hands of farmers to be considered a farm crop.

In the brief space of twenty years, however, the milos and kafirs have greatly increased in importance. They are now grown as staple farm crops on a large scale over a considerable area of the West.

ADAPTATIONS TO THE GRAIN-SORGHUM BELT.

It is in the western region previously described that the grain sorghums prove themselves most completely at home. They are here not only staple crops, but they are often the chief dependence of the new settler, because they may be grown as sod crops. By homesteaders with small means and limited equipment, they can be cheaply planted on breaking. They are often planted, cultivated, harvested, and even thrashed by hand under such circumstances.

When these crops were first introduced they were tried in various parts of the United States. One after another they were found unsuited to the conditions in most of the country and were discarded. But out on the Great Plains they grew in favor with the farmer because they were able to stand the prevailing conditions. They are able to grow and make profitable yields in hotter, drier climates than most crops. Some of them are early enough for use at comparatively high elevations. They are all cultivated crops, entering readily into the rotation with small grains. They furnish the feeding grain required on the farm, also some roughness, and occasionally both fuel and food in addition. The surplus can always be sold at fair to good prices. When grown on a large scale they are handled rapidly and profitably by machinery in every necessary operation from seeding to milling. They are undoubtedly suited to become the basis of a cattle-feeding industry that will make the Great Plains farmer prosperous.

USES OF THE GRAIN.

STOCK FEED.

Primarily these grains are and ought to be useful in feeding stock on the farms where they are grown. This fact accords with the history of these crops and is due to their adaptations for such use. They were the principal crops of the early settler in the dry-land areas of the southern Great Plains region. He not only needed a feeding grain but was often too far from market to sell it profitably if he had wished.

The value of the grain for keeping work stock, growing animals, and dairy cows in excellent condition has long been recognized among the growers. The knowledge of its value in fattening cattle and hogs for

market is increasing. A number of experiments to determine the feeding value have been conducted at the agricultural experiment stations of Kansas,[a] Oklahoma,[b] and Texas.[c] In many of these trials the Blackhull-kafir grain, which was most generally used, was shown to have a feeding value little below that of corn.

Table I shows the average chemical composition of a large number of samples of grain sorghums. In order to show the range of variation in composition, the minimum and maximum percentages found are given also. The analyses of the grain sorghums were made by Dr. J. S. Chamberlain, of the Bureau of Chemistry, in cooperation with the Office of Grain Investigations of the Bureau of Plant Industry. For comparison, the minimum, maximum, and average percentages found in 208 analyses of corn kernels are reprinted from Bulletin 11 of the Office of Experiment Stations.

The average analyses of all the grain-sorghum samples and all the corn samples are fairly comparable. The 49 grain-sorghum samples were grown in 1905, 1906, and 1907, mostly in the Great Plains area. The 208 corn samples were grown in many different States and years. The average composition of 10 grain-sorghum samples and of 12 corn samples grown at different times and places, determined by Doctor Chamberlain, and reprinted from Bulletin 120 of the Bureau of Chemistry, is also included in the table. From these figures and from others based on fewer analyses, but covering both crops grown under similar conditions, it is known that they are not very different in composition. In general, the grain-sorghum kernels average a little higher than corn in protein content and a little lower in ether extract, or fat, and in fiber. The range of variation in the protein content, from 7.93 to 16.63 per cent, indicates that high-protein varieties and strains can probably be readily developed by selecting for this quality.

[a] Bulletin 56, Kansas Agricultural Experiment Station.

[b] Bulletins 35, 37, and 46, Oklahoma Agricultural Experiment Station.

[c] Bulletins 95, 97, 104, and 110, Texas Agricultural Experiment Station; also an unnumbered circular of the Texas Agricultural Experiment Station entitled "Panhandle Feeds for Beef Production."

TABLE I.—*Composition of grain-sorghum kernels and corn kernels.*

Crop and percentage.	Number of analyses.	Water.	Water-free substance.				
			Ash.	Crude protein (N×6.25).	Fiber.	Carbohydrates.	Ether extract.
Milo:							
Minimum	....	9.82	1.57	10.34	1.73	78.91	2.89
Maximum	....	11.08	1.95	14.34	2.11	82.67	3.31
Average	8	10.61	1.77	12.41	1.86	80.87	3.09
Dwarf milo:							
Minimum	....	10.18	1.80	11.35	1.68	79.75	2.59
Maximum	....	10.52	2.06	12.84	2.66	81.92	3.51
Average	4	10.34	1.93	12.08	2.02	80.73	3.24
White durra:							
Minimum	....	9.70	1.93	7.93	1.49	78.33	3.34
Maximum	....	10.16	2.43	12.39	2.32	84.90	4.31
Average	5	9.87	2.17	11.22	1.85	80.81	3.95
Blackhull kafir:							
Minimum	....	9.87	1.80	9.93	1.84	76.88	3.36
Maximum	....	10.16	1.97	15.64	2.39	82.12	3.73
Average	5	10.05	1.90	13.69	2.08	78.87	3.46
Red kafir:							
Minimum	....	10.16	1.60	12.04	1.68	78.11	2.46
Maximum	....	10.55	2.05	14.47	2.91	81.26	3.45
Average	3	10.31	1.78	13.01	2.14	79.95	3.12
Brown kowliang:							
Minimum	....	9.75	1.76	8.80	1.46	79.13	4.27
Maximum	....	10.86	2.26	12.13	2.59	82.83	4.95
Average	7	10.26	2.12	10.51	1.75	80.98	4.64
Blackhull kowliang	1	9.99	1.96	11.52	1.63	80.18	4.71
White kowliang	1	10.05	2.40	11.53	1.39	79.53	5.15
Shallu:							
Minimum	....	9.37	1.42	13.01	1.73	76.42	2.57
Maximum	....	10.06	2.12	15.24	1.96	80.87	4.33
Average	3	9.70	1.76	13.88	1.85	78.78	3.73
Grain sorghums:							
Minimum	....	9.37	1.36	7.93	1.39	76.42	2.46
Maximum	....	11.08	2.43	16.63	2.91	84.90	5.15
Average	49	10.22	1.93	12.23	1.92	80.06	3.86
Average of other samples[a]	10	11.71	1.75	11.71	1.80	81.58	3.16
Corn grown in many States and different years:							
Minimum	....	4.50	1.10	7.70	.80	67.20	1.80
Maximum	....	20.70	3.10	17.00	5.70	84.80	12.80
Average	[b]208	10.89	1.70	11.70	2.40	78.10	6.10
Average of other samples[a]	12	13.06	1.52	9.91	2.21	81.96	4.40

[a] Chamberlain, J. S. The Feeding Value of Cereals, as Calculated from Chemical Analyses, Bulletin 120, Bureau of Chemistry, U. S. Dept. of Agriculture, 1909, p. 42.
[b] Jenkins, E. H., and Winton, A. L. A Compilation of Analyses of American Feeding Stuffs, Bulletin 11, Office of Experiment Stations, U. S. Dept. of Agriculture, 1892, pp. 16–17.

Table II gives some analyses, on the air-dry basis, made by the Texas Agricultural Experiment Station and published in Bulletin 95 of that station. Chops are composed of thrashed grain, more or less finely chopped or crushed. Head chops are made by chopping the unthrashed heads, and are therefore similar to and comparable with the corn-and-cob meal. The high fiber content of these last-named products is due, of course, to the woody panicle branches and cobs. The fiber content of thrashed seed, free from the glumes, seldom runs higher than 2 or 2.5 per cent.

TABLE 11.—*Composition of chops, head chops, and corn-and-cob meal.*

Crop and product.	Number of analyses.	Air-dry substance.					
		Water.	Ash.	Crude protein (N×6.25).	Fiber.	Carbohydrates.	Ether extract.
Milo chops	14	9.66	2.30	10.73	3.05	72.22	2.78
Kafir chops	19	9.86	1.63	10.98	2.75	71.18	3.12
Corn chops	9	11.81	1.19	9.60	2.52	71.71	3.90
	475			9.30			4.10
Milo head chops	4	9.42	2.71	9.22	6.51	69.55	2.44
Kafir head chops	3	13.62	2.82	9.25	8.03	63.38	2.62
Corn-and-cob meal	10	10.01	1.28	10.14	7.10	68.78	3.69
	10		2.01	8.51	7.98		3.49

Many grain elevators in the Great Plains region have been equipped with machinery for thrashing and grinding these grains. The grain should be cracked or ground before feeding to get the best results. In the form of milo chops and kafir chops, it is becoming a popular

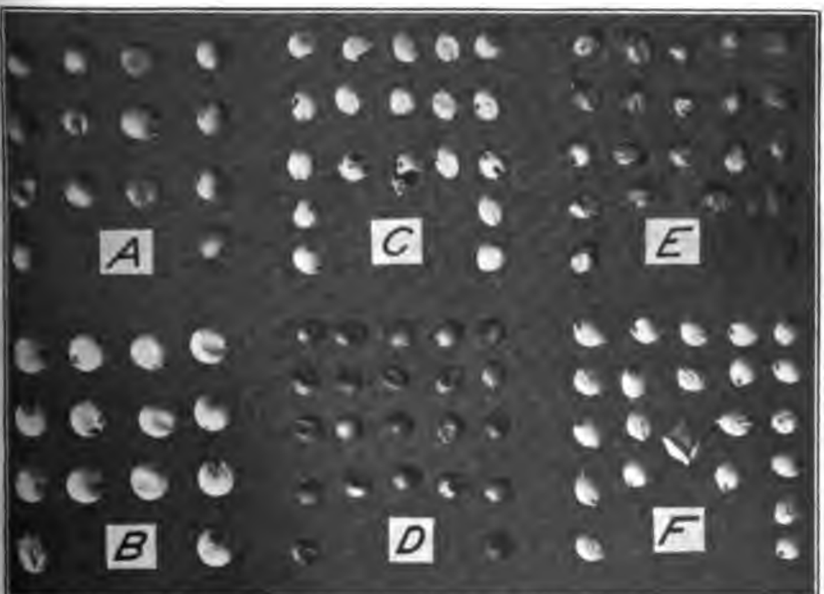

FIG. 3.—Seeds of grain sorghums: *A*, Milo; *B*, White durra; *C*, Blackhull kafir; *D*, Red kafir; *E*, Brown kowliang; *F*, shallu. (Natural size.)

commercial article. Head chops are not meeting with as much favor because of the included "dirt," composed of the glumes, glume hairs, awns, etc. It is for this reason that the elevators have installed thrashing machinery.

POULTRY FEED.

The grain-sorghum seeds (fig. 3) are splendidly adapted, both in size and composition, for feeding to all classes of poultry. In many parts

of the country, outside the grain-sorghum belt, small patches of kafir, durra, or other "chicken corn" are commonly grown on the farm simply to furnish chicken feed.

In 1908 inquiries were addressed to 114 firms manufacturing over 200 brands of poultry food. Data received from 33 firms show an annual output of about 30,000 tons of these products. Of this total quantity about 10,000 tons, or one-third of the total, consisted of Blackhull kafir seed. This was mostly used in mixtures with other grains, as corn, wheat, etc. From these facts it is probably safe to conclude that kafir or other grain-sorghum seed forms at least 25 per cent of the prepared poultry food sold in this country. So strong is the demand for these grains by poultry-food manufacturers that similar varieties have been imported from as far away as India when the crop in this country was short. Such importations are being made at the date of writing.

HUMAN FOOD.

Meal made from the grain sorghums ground locally is not infrequently used in the making of batter cakes and similar articles of food on the farm. The general testimony is that these are delicious in quality. Some experiments are now being conducted in a small way to determine the value of the meal for more extended use. There seems little reason why, when properly milled, it should not be used in much the same manner as corn meal. Throughout Africa, India, and the other parts of southern and eastern Asia, where these crops are largely grown, they are not only commonly used as human food, but in many countries they furnish the chief article of diet.

STATISTICS OF ACREAGE, YIELD, AND VALUE.

SCOPE OF DATA.

Complete statistics of the production of grain-sorghum crops are not available. The national census, taken every ten years, has not yet separated them in its schedules from other related crops. Of the five or six States which grow them largely, only two—Kansas and Oklahoma—gather state statistics of farm crops. The figures have been gathered in Kansas since 1893, but in Oklahoma only since 1904 for kafir and since 1905 for milo.

TOTAL GRAIN-SORGHUM CROPS IN KANSAS AND OKLAHOMA.

Table III shows the acreage, yield, and value of grain sorghums grown in Kansas and Oklahoma for a series of years. These results have been compiled and adapted from the figures given in the reports of the State Board of Agriculture for each of the two States.

In the Kansas figures three groups of grain sorghums are included, namely, kafirs, milos, and White durra ("Jerusalem corn"). Since

the area devoted to the White durra has not been larger than 4,000 acres but once in the last fifteen years, it may be neglected and the figures regarded as representing only kafirs and milos—the two staple crops. The yield for Kansas is shown in tons of fodder per acre, instead of bushels of grain.

In the figures for Oklahoma two groups of grain sorghums are included, namely, kafirs and milos, except for the first year, 1904, in which no returns were obtained for milo, and the figures given are for kafir only. For the years 1904 to 1906, inclusive, the returns are from only the former Territory of Oklahoma. For 1907 and 1908 they are from the entire new State, including the former Indian Territory. This probably accounts for the apparent sudden increase in acreage of 1907 over 1906.

The yield for Oklahoma is shown in bushels of grain per acre. The value of the crops is computed from the value of the grain alone for all the years except 1908. In that year returns were also made for the tonnage and value of the stalks. The value of the stalks has therefore been added to the value of the grain for that year to make the total value of the crops, from which the acre value is computed. The value of kafir stalks was found to be nearly one-half as much as the value of the kafir grain, or nearly one-third the combined value of both. The stalk value of milo was exactly one-fourth the grain value, or one-fifth of the combined value. It is not clear from the Oklahoma reports whether the fodder and grain represent the product of the same fields or whether the figures for fodder are intended to cover fields not used for grain. It is here assumed that the former was intended.

TABLE III.—*Acreage, yield, and value of total grain-sorghum crops for certain years in Kansas and Oklahoma.*

Year.	Kansas.					Oklahoma.				
	Acreage.	Yield in tons.		Value.		Acreage.	Yield in bushels.		Value.	
		Total.	Per acre.	Total.	Per acre.		Total.	Per acre.	Total.	Per acre.
1893	77,942	190,489	2.44	$553,320	$7.10	....	....	....	....	....
1895	231,498	793,154	3.43	2,079,285	8.98	....	....	....	....	....
1900	652,667	1,985,940	3.04	5,814,389	8.91	....	....	....	....	....
1904	528,142	1,609,038	3.05	5,136,412	9.72	334,948	3,280,510	9.79	$1,312,204	$3.92
1905	575,038	1,862,799	3.24	5,726,978	9.96	435,894	6,562,298	15.05	2,624,920	6.01
1906	569,701	1,727,965	3.03	5,216,985	9.16	391,565	6,513,928	16.63	2,336,704	5.97
1907	533,007	1,561,943	2.93	5,919,197	11.10	502,771	6,757,197	13.44	4,023,130	8.00
1908	688,582	1,908,551	2.77	7,407,516	10.76	545,143	5,529,219	10.14	3,305,765	6.06
1909	741,983	1,987,258	2.67	8,145,508	10.98	....	....	....	....	....
Average for years since 1904, inclusive	....	....	2.95	....	10.28	....	....	13.01	....	5.99

It will be noted that the total area devoted to grain-sorghum crops in Kansas was larger in 1900 than in 1905. The maximum acreage was reached in 1902, with a total of 757,000 acres. After 1902, the acreage decreased slowly until 1907, and then began a steady increase. It may be noted that in 1907, the year of lowest acreage, the highest value per acre resulted. In Oklahoma there has been a fairly constant increase in acreage during the years covered by the statistics. In both States there has been a general rise in the acre value of these crops. The figures do not indicate, however, that yields per acre are increasing.

KAFIR, MILO, AND CORN CROPS IN KANSAS AND OKLAHOMA.

Table IV shows the annual production of kafir, milo, and corn in Kansas and Oklahoma for the years since 1904, inclusive.

The proportion of grain sorghums to corn grown in these States is steadily increasing with the settlement of the drier western portions. The average acreage of grain sorghums for the period 1904 to 1909 in Kansas was equal to 8.7 per cent of the average corn acreage. For the year 1909 alone it had increased to 9.6 per cent in spite of an enormous increase in the corn acreage. In Oklahoma the same figures are not comparable because of the change from a small Territory to a larger State, but the average grain-sorghum acreage in the old Territory from 1904 to 1906 was equal to 25.6 per cent of the corn area. In 1907, in the new State, including both Oklahoma and Indian Territories, it was 12.5 per cent, and in 1908 12.7 per cent. The apparent decrease in the second period is due to the fact that Indian Territory grew much corn and little grain sorghum.

As pointed out before, the grain sorghums are all grown most extensively in the drier areas west of the ninety-eighth meridian. In Kansas about 45 per cent of the kafir and about 95 per cent of the milo is found west of this line, which divides the State almost exactly in half. In Oklahoma about one-third of the State lies west of this line and contains 79 per cent of the kafir and 98 per cent of the milo.

TABLE IV.—*Acreage, value, and yield of kafir, milo, and corn for the years 1904 to 1909, inclusive, in Kansas and Oklahoma.*

Crop and year.	Kansas. Acreage.	Kansas. Yield per acre in tons or bushels.	Kansas. Value. Per ton or bushel.	Kansas. Value. Total.	Kansas. Value. Per acre.	Oklahoma. Acreage.	Oklahoma. Yield per acre.	Oklahoma. Value. Per bushel.	Oklahoma. Value. Total.	Oklahoma. Value. Per acre.
Kafir:		*Tons.*	*Per ton.*				*Bush.*			
1904	518,372	3.04	$3.19	$5,041,546	$9.70	334,948	9.79	$0.40	$1,312,204	$3.92
1905	538,393	3.24	3.06	5,352,810	9.91	297,286	12.72	.40	1,512,318	5.08
1906	548,497	3.05	3.01	5,039,238	9.18	289,218	16.10	.34	1,465,937	5.44
1907	508,485	2.94	3.78	5,658,860	11.11	371,405	13.50	.58	2,881,632	7.77
1908	630,096	2.85	3.82	6,856,845	10.89	400,047	9.20	.46	a2,548,200	6.36
1909	636,201	2.79	4.02	7,150,080	11.21					
Average		2.99	3.48		10.33		12.26	.44		5.71
Milo:										
1904	7,166	3.18	3.22	73,476	10.24					
1905	20,550	2.84	3.28	190,974	9.31	138,608	20.06	.40	1,112,602	8.02
1906	17,563	2.55	3.26	146,289	8.31	122,347	17.82	.40	870,767	7.12
1907	22,090	2.72	3.90	234,686	10.61	131,366	13.30	.65	1,142,098	8.64
1908	55,255	1.92	4.85	515,269	9.31	145,096	12.55	.33	b757,565	5.22
1909	102,492	1.97	4.74	959,259	9.34					
Average		2.53	3.87		9.52		15.93	.45		7.25
Corn:		*Bushels.*	*Per bushel.*							
1904	6,494,158	20.3	.39	50,713,955	7.81	1,369,276	16.00	.39	8,544,339	6.24
1905	6,799,755	28.0	.36	68,718,584	10.11	1,642,930	18.90	.40	12,436,557	7.56
1906	6,584,535	28.4	.35	65,115,203	9.25	1,528,735	31.40	.36	17,142,081	11.21
1907	6,809,012	21.3	.43	63,040,743	9.26	4,014,631	18.10	.48	35,409,961	8.82
1908	7,057,535	21.3	.55	82,642,462	11.71	4,284,561	18.60	.48	38,449,866	8.97
1909	7,711,879	19.1	.57	83,066,905	10.77					
Average		23.1	.44		9.83		20.60	.42		8.56

a Includes $828,131 worth of fodder. b Includes $151,911 worth of fodder.

The 46 counties in the western half of Kansas grew, in round numbers, 240,000 acres of grain sorghums in 1907, 334,000 acres in 1908, and 396,000 acres in 1909. This was an increase of 39 per cent in the grain-sorghum acreage for 1908 and of 18.6 per cent for 1909. The same counties grew 1,500,000 acres of corn in 1907, 1,750,000 acres in 1908, and 2,000,000 acres in 1909, increases of 17 and 14 per cent, respectively. The ratio of the acreage of grain sorghums to that of corn was 1 to 6.2 in 1907, 1 to 5.3 in 1908, and 1 to 5.1 in 1909. The grain-sorghum acreage was therefore equal to 16.1 per cent, 18.9 per cent, and 19.5 per cent of the corn acreage of these three years, respectively. Ten of these counties grow larger areas of grain sorghum than of corn.

The 21 counties now comprising the western third of Oklahoma grew 327,000 acres of grain sorghum in 1906, 423,000 acres in 1907 (29 per cent increase), and 465,000 acres in 1908 (10 per cent increase). The ratio of grain-sorghum acreage to that of corn was 1 to 2.1 in 1906, 1 to 2.7 in 1907, and 1 to 3.1 in 1908. These ratios represent grain-sorghum acreages equal to 47.6 per cent, 37 per cent, and 32.2

per cent of the corn acreages for the same years. Four of these counties grow more grain sorghums than corn.

SUMMARY OF THE VALUES OF GRAIN SORGHUM AND CORN IN KANSAS AND OKLAHOMA.

In Table V is given the minimum, maximum, and average value per acre of grain-sorghum and corn crops in Kansas and Oklahoma. The figures are a summary of the values given in Tables III and IV. It will be noted that for Kansas the minimum acre value of the combined grain sorghums is not as low as the minimum for corn, that the maximum is nearly as high, and that the average acre value is higher by 45 cents an acre. In Oklahoma the relative positions of the crops are reversed.

Two facts must be kept in mind while comparing these figures. One is that for Kansas the yields and values of grain sorghums are based on tons per acre, and thus include the value of both grain and stover. The yields and values of corn, on the contrary, are based on bushels of grain per acre. If the value of the corn stover were also included, the average acre value for corn would probably somewhat exceed that of the grain sorghums. The difference, however, would probably not be as large as the Oklahoma figures show. The other fact is that the grain sorghums are most largely grown in the western parts of these States. Here the shorter seasons and lower rainfall tend to decrease the yields of all crops. This puts the sorghums at a disadvantage in a comparison with corn, which is most extensively grown in the lower and more humid portions.

TABLE V.—*Summary of values of grain sorghums and corn in Kansas and Oklahoma.*

State and crop.	Number of years.	Yield per acre.	Price per ton or bushel.	Acre value. Minimum. Year.	Acre value. Minimum. Value.	Acre value. Maximum. Year.	Acre value. Maximum. Value.	Acre value. Average.
Kansas:		*Tons.*	*Per ton.*					
Kafir	6	2.99	$3.48	1906	$9.18	1909	$11.21	$10.33
Milo	6	2.53	3.87	1906	8.81	1907	10.61	9.52
Total grain sorghums	6	2.95	3.48	1906	9.16	1907	11.10	10.28
		Bushels.	*Per bu.*					
Corn	6	33.10	0.44	1904	7.81	1908	11.71	9.83
Oklahoma:								
Kafir	5	12.26	.44	1904	3.92	1907	7.77	5.71
Milo	4	15.93	.45	1908	5.22	1907	8.64	7.25
Total grain sorghums	5	13.01	.44	1904	3.92	1907	8.00	5.90
Corn	5	20.60	.42	1904	6.24	1906	11.21	8.56

IMPROVING THE GRAIN SORGHUMS.

There are two general ways by which grain-sorghum crops can be made of greater value to the grower. First, by improving the varieties; second, by devising more rapid and economical methods of har-

esting. Improved varieties can be secured through selection of resent sorts (fig. 4), and by bettering the methods of planting them. Iore rapid and economical harvesting will come about either through dapting the crops to present machinery or through the invention of .ew machines, or both.

It is better to keep in view the results sought rather than the means ›y which these results are to be attained. The problems of improvement will therefore be discussed under headings showing the most

FIG. 4.—Plat of milo, selected for erect heads and low stature.

important results desired. These problems are five in number, namely, (1) increased drought resistance, (2) increased earliness, (3) dwarfness (or diminished stature), (4) greater productiveness, and (5) adaptability to machine handling.

DROUGHT RESISTANCE.

The grain sorghums find their greatest usefulness in regions where moisture is often the controlling factor in crop production. Much

good should therefore be accomplished by increasing their drought resistance, especially in the areas of lighter rainfall.

No one knows exactly what drought resistance is. It is probable that the character called drought resistance is one of several different factors or the result of a combination of two or more of them. The most important of these factors are probably (1) increased ability to prevent the loss of water by transpiration, (2) increased development of the root system, and (3) a possible increase in power to extract water from a dry soil.

Differences in the power to control transpiration are well-known and readily observed facts. In cacti, for instance, this ability is highly perfected. Corn is in danger when the leaves begin to curl, but sorghums often remain in this condition for a long time without permanent injury.

The size and character of the root system are probably a strong factor in drought resistance. The larger the root system in proportion to the plant, the better it can supply moisture. The wider and deeper its penetration, the larger the area of soil from which it draws moisture in time of drought. A deeply rooting plant may be able to secure water when shallow root systems lie wholly in dry soil. This is entirely apart from possible differences in ability to extract moisture from a given unit of soil. Such differences may exist, but the idea is yet only a theory. Unfortunately, the character of the root system can not be observed while making selections.

Selections for drought resistance will usually be made on observed phenomena. These are likely to be the result of a combination of adaptations for actual drought resistance and adaptations for drought evasion. Dwarfness, earliness, and thin stands are adaptations or conditions for drought evasion. Making allowance for these when present, one can select for actual drought resistance. This will be done by using those plants which give best results under dry conditions when they are neither dwarfer, nor earlier, nor more thinly planted than their neighbors.

EARLINESS.

ADVANTAGES TO BE GAINED.

The two principal reasons for desiring early varieties are, first, to extend the range of grain sorghums into dry regions having a short growing season; and, second, to obtain the fullest possible benefit from the seasonal rainfall, which comes largely during the early summer months in parts of the grain-sorghum belt. This second reason is thus connected with the problem of drought resistance, though, as pointed out, earliness is a means of drought evasion, not of resistance.

Improvement in earliness will need to be continued for a long time if varieties are to be perfected for the needs of all the dry-farming regions.

EARLY VARIETIES.

The milos (figs. 4 and 8) are much earlier varieties than the kafirs, and are very promising material on which to work. In the Panhandle of Texas, at elevations of 3,000 to 4,000 feet, they now mature in ninety to one hundred days when sown May 15 to 20. At present they are grown successfully at altitudes between 4,000 and 5,000 feet in Texas, New Mexico, and Colorado. At higher elevations the growing season is shortened to such an extent that the present

FIG. 5.—Plat of White durra with 100 per cent of the heads erect.

varieties of milo do not mature. At lower elevations their present range extends northward into southwestern Nebraska. In northern Nebraska, the Dakotas, Montana, and Idaho the increasing latitude and shorter growing season prevent their successful maturing. It seems certain, also, that the soil, especially at night, is too cool to permit vigorous growth, thus retarding the maturing of the plant even where the season is otherwise long enough.

The durra group contains some very early varieties. The only one well known in this country is the common White durra (fig. 5), which has been called "White Egyptian corn," "Rice corn," and "Jerusalem corn," in the successive periods of its popularity. I' matures as early as or slightly earlier than the milos. White durr

apparently possesses true drought resistance also, and is productive, but shatters quite badly and is not liked for that reason and some minor ones. Some hybrids of this variety with Blackhull kafir have been under selection for three years and give promise of being valuable.

The kafirs usually require about three weeks longer than milo to mature under the same conditions. An early strain of Blackhull kafir (fig. 6) developed by the writer, through selection, matures about two weeks earlier than the ordinary kafirs and only three to

FIG. 6.—Plat of dwarf and early Blackhull kafir (G. I. No. 340).

five days later than milo. The old-fashioned White kafir, with white hulls, now rarely found in cultivation, was a semi-early sort and would make good selection stock if its heads were free from the boot and if it were not so susceptible to disease. Red kafir, which is normally a week or more earlier than the Blackhull in the low plains, seems to become proportionally later as it is carried westward to higher elevations. At the Amarillo Experiment Farm it has been consistently later than the Blackhull for several years.

The group of kowliangs from North China and Manchuria contains some varieties (fig. 7) which are naturally very early, especially

among the brown-seeded sorts. Two or three (G. I. Nos. 171, 261, and 328) have matured in eighty to ninety days, thus proving earlier than the milos in the Panhandle of Texas. Some promising selections from them have been made in northern Colorado, in Nebraska, and in South Dakota. Coming, as they do, from latitude 40° or higher, they may prove able to germinate and grow at lower temperatures than the groups which have come from more southern latitudes.

EARLY CROPS AND EARLY SEASONAL RAINFALL.

The effect of earliness in permitting drought evasion is very important. Imagine two plants, one earlier than the other, but otherwise

FIG. 7.—Plat of selected Brown kowliang (G. I. No. 171)

similar in all respects. The earlier plant, having a shorter growing period, not only uses less water, but uses it earlier in the season. This is of especial importance in those parts of the semiarid country where much of the seasonal rainfall occurs in April, May, and June. The earlier plant might be able to mature its crop of seed on the summer rainfall. On the other hand, the later plant might be crippled at a critical stage by the exhaustion of the soil moisture during dry weather in August. It is fairly certain that in much of the Great

Plains region the greater part of the soil moisture in a field is not used by the growing crop, but is lost by evaporation, under the average tillage conditions.

Milos are earlier than kafirs, but are not known to be more truly drought resistant. At the experiment farm, Amarillo, Tex., under conditions of extreme drought from the middle of July until October, 1909, the milos yielded on the average 8.3 bushels and the kafirs only 5.5 bushels to the acre. In each crop the figures are the average of between 20 and 30 plats and show that the difference was really in the earliness of the milos as compared with the kafirs, the yields in normal years being about equal.

The writer has produced by selection a dwarf kafir (fig. 6) of the Blackhull variety which is nearly two weeks earlier than the ordinary strains. In 1908, a favorable season, it yielded less by 4.5 bushels than the average of the ordinary Blackhull varieties. In 1909 it yielded 14.4 bushels to the acre, while 20 ordinary strains averaged only 5 bushels, and the best of them yielded only 10.9 bushels. Part of the credit must probably be given to the dwarf stature because another selection, equally early but not dwarf, yielded only 10.7 bushels, as much, however, as any one of the later strains and twice as much as they averaged.

SELECTING FOR EARLINESS.

Earliness can be developed only by continuous selection. Such selections can be made either at heading time or at the time of ripening, but are preferably the results of records made at both periods. When the field or seed plat of the variety begins to head, a number of the earliest heads which are otherwise suitable for selection should be marked by means of tags on which is recorded the date of heading. When the heads on these selected stalks begin to show the characteristic colors and texture of the hard dough, or ripening stage, the date of ripening should be added to the tags. Other things being equal, those heads for which the shortest time has elapsed between heading and ripening are to be considered the earliest. These heads should be carefully saved separately and used for continuing the work another season.

In dry regions, where the amount of moisture in the soil is commonly the controlling factor in crop growth, the plants at the ends and sides of a field are often the first to produce heads, especially in dry seasons. This is because the outside plants have a larger area from which to draw moisture, or because run-off water often collects at the edges of fields and provides extra moisture. These early heads will be the first to ripen, but it does not follow that these plants are naturally earlier than the rest of the field.

DWARF STATURE.

For the grain-sorghum grower, a dwarf variety has two advantages over the taller strains. It requires less water and can be harvested with a grain header.

The larger the plant the more water it requires and the more it is likely to lose by transpiration. A small plant which can produce as much grain as a large plant will thus have a real advantage in a dry season. This is not true drought resistance, but merely a lower water requirement which permits drought evasion. The year 1909 was marked by severe drought during July, August, and September in the southern half of the Great Plains. At the Amarillo Experiment Farm, in Texas, 17 plats of milo gave an average yield of 6.8 bushels and 10 plats of dwarf milo an average yield of 11 bushels to the acre. The best plat of milo yielded at the rate of only 16.5 bushels, though in a low piece of ground, while the best dwarf milo yielded 23.2 bushels per acre. This advantage seems to be largely due to the smaller size of the plants of the dwarf variety and the consequent lower water requirement.

The development of an early dwarf strain of Blackhull kafir (fig. 6) has already been noted under the discussion of "Earliness" (p. 26). How much of its superiority was due to dwarfness and how much to earlier maturity can not be certainly known. Apparently about one-half was due to each cause.

The production of dwarf varieties has made possible the use of the grain header in harvesting the crop. Headers have been successfully raised on timbers until they will cut ordinary tall varieties, but this practice is not likely to become general. In case a successful row header is invented it is more likely to work well on low varieties than tall ones, especially in windy regions.

Selecting for dwarf stature raises the question of the ability of a plant to produce the same seed yields with a reduced stalk and leaf area. How far can reduction in the size and height of stems be carried without a reduction in the leaf area? How far can reduction of leaf area be carried without reducing grain production? These questions can not be answered except by long-continued investigations. It is much to be hoped that a series of careful and comprehensive experiments may some time accumulate data on the correlation of area of leaf surface and the power of seed production. The dwarf milo (fig. 8) and dwarf kafir are only 3 to 4 feet in height under conditions that make the normal crop 5 to 6 feet in height. The dwarf milos outyield the standard milos even in favorable seasons. The White durra, which is low, yields as much as the kafirs, which are of medium height or taller. The dwarf kafir seems likely

to hold its own in a series of years. An extra-dwarf Brown kowliang has been secured in China. It grows to a height of about 2 feet, but, like most newly introduced sorghums, does not show high yielding power.

These crops have originated in subtropical lands and are commonly inclined to large growth. While they have been used chiefly for grain production in their native homes, it has been by more or less primitive peoples, and the returns have not been large. Since coming to this country, most of the standard varieties have been reduced in

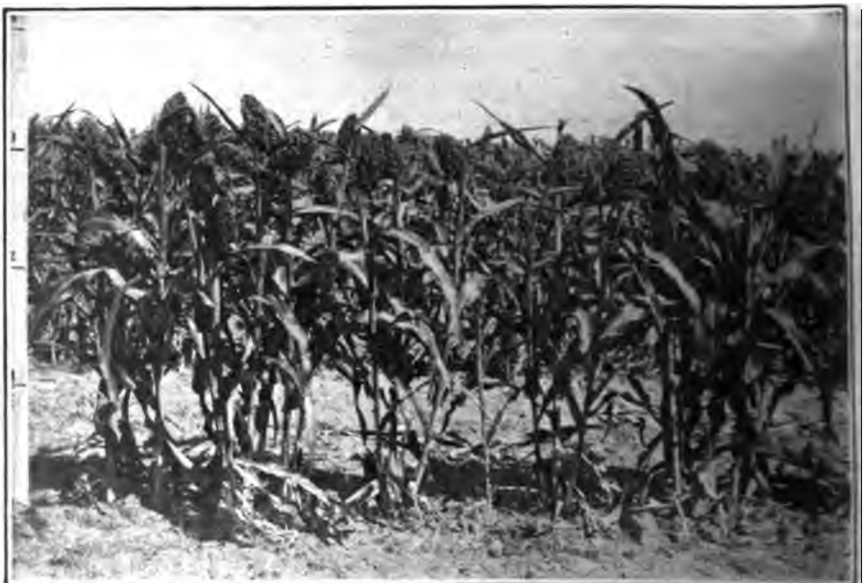

FIG. 8.—Plat of select Dwarf milo.

size and at the same time have increased in yielding power. The limit of profitable dwarfness has probably not been reached; it certainly has not been passed.

PRODUCTIVENESS.

OUTLINE OF THE PROBLEM.

The two keys to increased grain yields are better varieties and better methods of growing them. Better varieties means better filled and perhaps larger heads, erect and fully exserted from the boot, borne on stalks with fewer suckers and no branches. Better methods relate to proper and even spacing of stalks in the row and to thorough cultivation of the growing crop. They also include proper rotations and suitable tillage of the land when not in crop. Selections for better yields may naturally be continued as long as

the crop is grown. No one may say what returns will finally be obtained. It may reasonably be hoped, by continued effort, to double the present average yields.

Better Yielding Varieties.

METHODS OF SELECTION.

The origin of a better yielding variety need not be at an experiment station or other like source; it may be produced by the farmer himself from his own fields. In any event, the grower must continue the selection from year to year. In its simplest form this will mean the selecting

Fig. 9.—Two heads of milo, showing desirable and undesirable types.

of stalks of desirable size and habit, bearing large and well-shaped heads (figs. 9 and 10), well loaded with plump grains. This requires, of course, that the work of selection be done in the field. Selections made in the bin or crib would be without value in this regard. The work should be done before harvesting begins, and a sufficient quantity selected to furnish plenty of seed for the farm crop of the next year. Where the harvesting is done by hand and the seed selections

have not been previously made, the two operations can be combined though not usually with complete satisfaction. A small box fastened to the near side of the wagon bed will serve to receive the selected heads. Where machine heading is practiced this method is, of course, not possible.

DESIRABLE FORMS OF HEADS.

Well-filled heads.—It is important that the heads be well filled at the butts and tips, as in high-grade corn ears. Less attention has been given to this matter than it deserves. Figure 9 shows desirable

FIG. 10.—Two plants of Blackhull kafir, 5½ feet high, selected for high yielding power.

and undesirable types in milo heads, and figure 10 shows desirable heads of Blackhull kafir. Milo may be taken as representing durra also, while the kafir may be regarded as the proper shape for kowliang as well. The poorer head contains less grain and is therefore less productive. It also contains a larger proportion of fiber, and hence is less valuable as a feeding ration.

The heads selected should have shorter branches at the butt than in the rest of the head. These basal branches should be loaded with

ed down to the point where they join the rachis or central stalk of ie head. Long basal branches are likely to droop and finally break way under the combined stress of weight and wind.

Fully exserted heads.—It is also important that the head be fully xserted from the boot, or upper leaf sheath. No seed is produced on he included portion, which often becomes moldy or rotten if wet eather prevails. Corn worms and false army worms (*Laphygma rugiperda*) breed in such places and add to the injury. When these eads with spoiled butts are piled with others they are likely to cause lamage to the whole heap. Varieties in which the heads are not ully exserted are also more difficult to harvest by hand or machine.

The main agricultural difference between White kafir and Blackıull kafir is that the heads of White kafir never become fully exserted from the boot. White kafir was the first kafir variety to come into general cultivation in this country, but has since been almost wholly discarded, largely for this reason. Blackhull kafir, the present popular variety, bears the heads normally entirely free from the boot (fig. 10).

Large heads.—In selecting for large heads the proportionate size of the stalks must always be considered. Not the largest head alone, but the largest possible head on the smallest stalk is the most desirable selection. The grain sorghums are for use where limited rainfall is the principal controlling factor in grain production. Larger plants use and transpire more water than smaller ones. Selection should be made where the stand is uniform and fairly thick, and should include the largest and best heads produced under such conditions. They should not be made from the outer row of the field or plat, or from places where the stand is thin, even though the larger heads are found in such places.

Average weight of heads.—Close spacing of stalks in the row or an unfavorable growing season reduces the size of the heads, even if they are well filled. The average weight of heads also varies with the stand and seasonal conditions. Wide spacing and favorable conditions cause larger and heavier heads. Under average field conditions the heads of milo, Dwarf milo, and kowliang weigh from 3 to 4 ounces, and those of durra varieties about 3 ounces each. In the kafir group the heads are normally much heavier, weighing from 4 to 6 ounces.

PERCENTAGE OF GRAIN IN TOTAL PLANT.

It is unfortunate that during the years when these plants were new in this country no records were kept of the proportion, by weight, of seed to total plant. Such data covering a considerable period of years at the same point would show not only the progress made, but would be an index to what might be expected in the future. During

the past four years an attempt has been made to gather data on this subject. Even if the experiments had not been interrupted by drought, hail, and other environmental factors, four years is too short a period to yield conclusive data of this sort.

Table VI contains the average results obtained from a number of plats of several varieties. These results are not at all conclusive, but merely indicative of possibilities and are so offered. Of the four years considered, two have been favorable and two unfavorable crop years. The years 1906 and 1908, especially at the Amarillo Experiment Farm, were reasonably favorable seasons, as will be seen from the recorded yields. In 1908, however, the milo plats at Amarillo were almost wholly destroyed by hail, and must therefore be omitted. Their comparison with the Dwarf milo grown the same season would have been interesting. The years 1907 and 1909 were seasons of more or less drought by which the grain yields were usually reduced more than the vegetative growth. The figures for the four years are, therefore, not comparable.

TABLE VI.—*Percentage of grain in total weight of plants.*

Variety and number of plats averaged.	Grown on Texas farm at—	Year.	Row space per stalk.	Plants. Weight per acre.	Grain. Weight per acre.	Grain. Proportion in total plant.	Grain. Yield per acre.
			Inches.	*Pounds.*	*Pounds.*	*Per cent.*	*Bush.*
Milo:							
6	Amarillo	1907	8	5,375	1,434	26.5	24.7
3	..do	1907	4	5,274	868	15.6	15.0
7	Dalhart[a]	1908	10	3,854	1,462	37.9	25.2
1	..do	1908	30	3,150	830	26.3	14.3
3	Amarillo	1909	7	5,353	789	15.0	13.2
Dwarf milo:							
5	..do	1908	8	6,208	2,366	38.1	40.8
1	Dalhart[a]	1908	10	4,400	1,461	33.2	25.2
1	..do	1908	30	3,250	969	29.8	16.7
2	Amarillo	1909	8	3,807	1,007	25.7	18.3
Blackhull kafir:							
3	..do	1906	9	10,317	2,692	26.1	44.9
5	..do	1907	9	8,334	1,240	15.2	21.4
4	..do	1907	5	9,145	1,155	12.6	19.9
5	..do	1907	14	7,052	830	11.8	13.6
5	..do	1908	10	7,798	1,966	25.2	32.6
Brown kowliang:							
1	Dalhart[a]	1908	23	2,000	725	36.2	12.5
5	Amarillo	1909	5	3,546	934	26.6	16.1
Shallu:							
1	..do	1906	....	7,100	1,565	22.0	26.1

Another varying factor, which affects not only the yields but also the proportion of grain to plant, is the stand secured or the inches of row space afforded each stalk. In some of the experiments this factor was purposely varied, as in the two groups of milo and Blackhull kafir at Amarillo in 1907 and the milo and Dwarf milo at Dalhart in 1908. Unintentional variations occurred, caused by differences in the size and quality of the seed or in the nature or preparation of the

[a] In cooperation with the Office of Dry-Land Agriculture Investigations.

land. These produced nearly as great differences in the stand as were caused by the different rates of seeding. The average row space is shown in column 4. It may be noted that from 7 to 8 inches is considered the proper row space for milos and 9 to 10 inches for kafirs under Panhandle conditions.

The highest proportion of seed to plant was given by Dwarf milo at Amarillo and by milo at Dalhart in 1908. Two of the five plats of Dwarf milo at Amarillo, 1908, gave a proportion of over 40 per cent. As noted, the milos, which would have been comparable, were destroyed by hail. Of the seven plats of milo averaged at Dalhart, in 1908, three yielded higher than 40 per cent of grain, the highest being 47.2 per cent, which is probably the maximum yield for this crop.

Many other factors enter into the problem of increased productiveness. All the preceding discussion on earliness, drought resistance, and dwarf stature applies to this topic in some measure, as has been seen. However, the fact remains that no matter how great the performance of a plant under any given set of conditions it is possible to increase its producing power.

FREEDOM FROM SUCKERS AND BRANCHES.

Plant habits.—The habit of producing both suckers and branches is apparently characteristic of all sorghums, though in varying degrees. Suckers seem to be produced normally, but branches grow only under somewhat exceptional conditions. They will therefore be discussed separately.

Suckers.—Suckers are produced from the closely crowded lower nodes or joints of the stem just at the surface of the ground. In some plants suckers appear almost as early as the main stalk itself. In other cases they do not develop until the main stalk is well grown, or even after it has begun to mature its seed. Suckers may vary in number up to 10 or 15, according to the habit of the plant or to the particular environmental conditions, such as abundance of food and moisture. Though their heads are usually smaller, suckers differ from the main stalk chiefly in height and time of maturity. They are usually rather lower and almost always later in maturing, often very much so. Where the later part of a season is more favorable than the earlier, suckers often grow taller than the main stalk. Their difference in stature is objectionable only in harvesting, but their late ripening is a more serious matter.

The value of suckers in grain-sorghum crops is still a debated question. Many of the advertisements offering the seed of these crops dwell at length on their power to produce several stalks from one seed. Considering the cheapness of the seed of grain sorghums and the exceedingly small quantity (2 to 4 pounds) needed to plant ar

acre, the grower can well afford to require only a single stalk from a single seed. In a forage crop, where abundance of leaves is wanted, suckers may be very desirable, but in a grain crop requiring little seed, the weight of evidence is against them. Their existence may be partly justified by their help in making a fuller crop where a thin stand occurs. This is largely offset by their somewhat later maturing. It is a question whether the seed produced really pays for the food and moisture used.

Selections should then be made with the object of entirely removing suckers. This can best be done by selecting seeds from stalks which produce none. If the crop on which selection is begun does not contain any stalks wholly without suckers, the selection should be made from stalks which have only a single sucker, or in which the suckers are very small and appeared very late in the season. In this way the tendency to produce them will gradually be overcome. Closer planting in the drills will also have this effect. The combined effect of these two methods will materially reduce the number of suckers.

Branches.—Unlike suckers, branches do not appear until the main stalk is headed out and usually not until it has nearly ripened its seed. In all sorghums the main head is borne on a long peduncle arising from the uppermost node. There is no lateral bud at this node; at all other nodes, however, there is borne a single lateral bud. lying in the slight furrow or concavity of the internode and fully protected by the tough, convolute leaf sheath arising from the node and completely enveloping the internode. Branches are most likely to be produced when the weather remains warm and there is abundant moisture late in the season. The bud at the internode below the one bearing the terminal peduncle begins to develop into a plant. It forces its way out, either at the ligular collar of the sheath or by splitting the dorsal surface of the sheath, and then rapidly elongates, putting out leaves and finally a terminal seed head. It thus becomes a miniature stalk, growing on the parent stalk and exactly like it in all respects except size. In the meantime the buds at the successively lower nodes have been making similar growth. If the season is long enough and the moisture sufficiently abundant all these developing buds will become fruit-bearing stalks. In extreme cases the lateral buds on the oldest or uppermost branches will themselves develop into branches. This compound branching could go on indefinitely if permitted by seasonal conditions.

The heads on these branches are much smaller and less productive than those on the main stalk. They are also much later in maturing. Advertisements which state that a single stalk produces 4 to 10 large heads are wholly misleading. The branches themselves, arising

first from the upper nodes, make the plant top-heavy and likely to lodge. The presence of branches interferes decidedly with the harvesting of the grain. When branching begins before the head on the main stalk is ripe its maturing is usually delayed. Branches use moisture that is often needed to be conserved for the next crop without making any adequate returns. These facts make the production of branches objectionable and they should be eliminated by selection and proper planting wherever they tend to occur.

Better Methods.

SCOPE OF TREATMENT.

Only methods of planting and the proper cultivation of the crop will be treated here. Rotations and general tillage to conserve moisture have their influence on crop improvement. In a new country, however, strict rotation systems can not be followed, and the general methods of dry farming can not be given in the limits of this paper. The principles are two: (1) Till so as to absorb the rainfall, (2) till so as to prevent evaporation. This subject has been fully treated elsewhere.[a]

PROPER STAND OR ROW SPACE.

The whole question of the proper stand or row space for the different varieties, under different conditions of soil and moisture, is one of which little is yet known. It is not the plant having the largest head which makes the heaviest acre yield, but the plant which can produce the largest head while growing in the smallest possible row space.

The results of four years' experiments at the Amarillo Experiment Farm, Texas, indicate that in general the kowliangs yield best with a stand of 1 stalk in each 5 or 6 inches of row; the milos and durras with 1 stalk in each 7 or 8 inches of row; and the kafirs with 1 stalk to each 9 or 10 inches of row. The rows are always 3½ feet apart and, as far as possible, the seeds are dropped singly in the rows (fig. 11). Under these conditions improved varieties in each of these three distinct groups give approximately the same yields. The Amarillo Experiment Farm has an elevation of 3,600 feet and an average annual rainfall of 22 inches, the larger part of which comes during the growing season. Further investigation, continuing the experiments through a longer period of years, may discover that better average yields will be produced at other spacings than those noted above.

[a] See Farmers' Bulletin 266, entitled "Management of Soils to Conserve Moisture," which will be sent free on application to the Secretary of Agriculture, Washington D. C., or to any Member of Congress.

It is probable that at other locations better results will be obtained at other rates of planting than those given for Amarillo. The rate will vary with different elevations, different amounts of annual rainfall, or a different proportion of it during the growing season, and with differences in the character of the soil.

DRILLS OR HILLS.

Another important question which has not yet been made the subject of experiment to any great extent is the comparative value of planting in drills and in hills. For instance, 1 stalk every 6 inches in the row, or 2 stalks in a hill every foot, or 3 stalks in hills 18 inches

FIG. 11.—Plat of Brown kowliang, showing stalks singly and evenly spaced in the row.

apart, or 4 stalks in a hill and the hills 2 feet apart, would all give the same number of stalks per acre. Would they give the same results in bushels of grain per acre? The answer is not known. All the evidence at hand indicates that the advantage is in favor of a single stalk in a place. Experiments with corn seem to show that where from 3 to 5 kernels are planted in a hill, results are better if the kernels are scattered a few inches apart instead of being dropped in a bunch.

Aside from the immediate question of yields, however, there are other reasons for preferring planting in drills rather than in hills. These reasons are connected with the production of suckers and pendent heads. Observation indicates that the fewest suckers and

pendent heads are produced where the stalks stand singly. Whether this be true or not, it is certain that where the stalks stand one in a place it is much easier to determine if suckers are produced and to take steps to get rid of them by selection.

PLANTER PLATES.

The difficulty of attaining proper rates of planting is partly psychological and partly mechanical. When the psychological objection is overcome the mechanical hindrance can easily be removed. The first sorghums extensively cultivated in this country were the sorgos, which are forage crops and as such are planted thickly. The other leading groups, the milos and kafirs, were also first regarded as forage plants and sown thickly. Corn planters were equipped with "cane" plates which dropped 10 to 25 seeds in a foot of drill. In this way the idea of thick seeding for sorghums became firmly fixed in the minds of growers.

The value of the milos, kafirs, and durras as grain producers was only gradually recognized. The necessity of planting thinly where high grain yields are desired was realized even more slowly. Though this necessity is now being seen by the great body of grain-sorghum growers, there is not yet knowledge and agreement as to the proper rates of planting. These vary with different conditions and must be made the subject of extensive experiments. In the meantime the manufacturers of planters, though recognizing the demand for different plates, have had little data on which to create a suitable supply.

So far as the size of the seeds is concerned probably only two sets of plates will be necessary in order to drop a single seed at a time of any variety. The two sets will have the holes of different sizes and perhaps of slightly different shapes also. Milos and durras have rather large seeds, more or less round in outline. Kafirs and kowliangs have smaller and oval seeds.

Having these two sets of plates, certain variations in the rate of planting will be necessary in order to space properly the seeds of different varieties in the drill. For instance, the seeds of kafirs and kowliangs will drop singly through the same hole, but the one should be planted 10 inches apart and the other only 5 inches. This variation in rate may be effected either by the adjustment on the planter which changes the speed of the plate or by using plates drilled with different numbers of holes. Where plates with the proper number of holes are not purchasable, blank plates can be bought and drilled by a blacksmith. Care should be taken that the holes are countersunk on the lower side of the plate so that seeds will not become wedged in them.

ADAPTABILITY TO MACHINE HANDLING.

GENERAL STATEMENT.

More than ever is it true that the demand is for crops which may be handled readily and profitably by machinery at every stage in their production. This has long been true of the small-grain crops. Corn and cotton are examples, however, of two great staple crops which must still be gathered by hand. The economic pressure is so great, however, that many and varied efforts are being made to produce machines which will gather the ears of corn and the fleecy staple of the cotton.

HEADERS.

If the grain sorghums are to become staple crops on a large scale they must be adapted to machine handling. In the early years of the cultivation of milo and kafir as important crops there were two methods of harvesting in vogue where seed was desired. The first was to cut the crop, stalk and all, with the corn binder and cure it in the shock. The heads were then cut from the bundles with a knife, saw, or hatchet. The second method was to cut the heads by hand in the field. This was done with a knife, and the heads were thrown into a wagon body, like ears of corn. Both these methods are in common use to-day.

A header designed for use in heading kafir was invented some years ago. Though still in use to some extent, this header has never been a popular or widely used machine. It is a rather heavy machine, not running upon its own gear, but attached to the side of the wagon box. It is heavy and hard to handle, destructive to the wagon bed, and not susceptible of quick and wide adjustments. Moreover, it heads but a single row at a time, and is rather expensive, considering all these points. It can not be used on milo because of the large percentage of pendent heads, nor on Dwarf milo because of its low growth. In recent years many attempts have been made to invent a satisfactory row header which would be free from the objectionable features mentioned. So far these have not been successful, though one of them gives considerable promise.

Since the introduction of Dwarf milo it has been found possible to harvest it rapidly and satisfactorily by means of the ordinary grain header. The standard milo and the kafirs are too tall for easy handling with this machine. A few ingenious farmers have, however, contrived to raise their headers on planks to a point where they will gather these taller crops with a fair degree of satisfaction. One great advantage of the grain header is that it enables the farmer to harvest his small grains and his feeding grains with the same machine. As

; cuts a number of rows at a time the work is done rapidly and a ırge area is easily harvested.

Two facts still prevent the general use of the grain header for these rops, namely, their height and the presence of pendent heads in ome varieties. Here is a problem in selection for the farmer. Dwarf trains of kafir must be produced to equal the Dwarf milo already so ›opular. Varieties with erect heads must be had in all milos and lurras.

PENDENT HEADS.

There are four great groups of grain-producing sorghums now under cultivation in this country. These are milo, durra, kafir, and kowliang. The first two groups originally had pendent heads (fig. 12). In the last two groups the heads are normally erect. The durras are but little grown because of the wasteful shattering of the seed, the irritating hairs on the glumes, and the pendent heads. A strain of White durra has been perfected in which 100 per cent of the heads are erect under all conditions. Improvement in the milos has not progressed so far. The percentage of erect heads varies from 50 to 95, depending, perhaps, more upon the season than on the particular strain. The character of pendent heads does not yield readily to selection. It doubtless can be entirely eliminated, however, by long-continued selections.

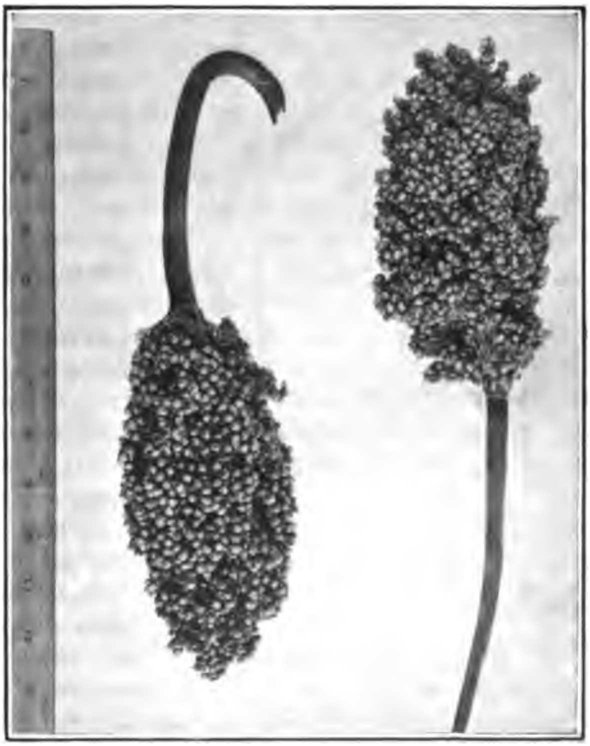

Fig. 12.--Milo heads; one pendent, one erect.

The tendency of the head to hang downward on a recurved peduncle is an inherent one. Because the largest heads are most likely to be

of early seasonal rainfall and also have lower water requirements. Milos, White durra, and some Brown kowliangs are normally early. An early dwarf strain of Blackhull kafir has been produced. Dwarf stature lowers the water requirement of the crop and permits heading by machinery.

Better yielding varieties may be produced by selecting for well-shaped, well-filled heads, fully exserted from the boot, and as large as possible in proportion to the size of the stalk.

The value of suckers in the grain-sorghum crops is doubtful. They are often shorter and usually later in maturing. Seed is so cheap and so little is used per acre that only a single stalk from each seed need be required. Branches should be eliminated, because their objectionable features render them utterly worthless for grain production.

Experiments show that under Panhandle conditions kowliangs give best yields with a stand of 1 stalk to each 5 or 6 inches of 3½-foot rows; milos and durras each 7 or 8 inches, and kafirs each 10 inches. Under different conditions the spacing will need to be varied somewhat.

Better results are probably secured from plants single in the drill than from the same number of plants in hills. Single stalks are also more easily selected and harvested and seem to produce fewer suckers. To plant single seeds of the different grain sorghums two sets of plates are needed, with holes of different sizes; one set for milos and durras and one for kafirs and kowliangs. To space different varieties properly in the drill, speed adjustments on the planter or plates with different numbers of holes will suffice.

The ordinary grain header harvests low varieties like dwarf milo with complete success. The invention of satisfactory row headers or the creation of other dwarf varieties will finally solve the harvesting problem.

Pendent heads are usual in some varieties. They can be slowly eliminated by selection and proper planting.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 204.

B. T. GALLOWAY, *Chief of Bureau.*

GRICULTURAL EXPLORATIONS IN THE FRUIT AND NUT ORCHARDS OF CHINA.

BY

FRANK N. MEYER,
AGRICULTURAL EXPLORER, FOREIGN SEED AND PLANT INTRODUCTION.

ISSUED MARCH 25, 1911.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

BUREAU OF PLANT INDUSTRY.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., September 26, 1910.

SIR: I have the honor to transmit herewith and to recommend for iblication as Bulletin No. 204 of the series of this Bureau a manuript entitled "Agricultural Explorations in the Fruit and Nut rchards of China," by Mr. Frank N. Meyer, Agricultural Explorer. his manuscript has been submitted for publication by Mr. David airchild, Agricultural Explorer in Charge of the Office of Foreign eed and Plant Introduction.

Mr. Meyer's explorations in China, Manchuria, and Korea have rought to the attention of the Department many plants which prome to be of value to our agriculturists, either as forming the basis for ew industries or as providing new and valuable strains of plants lready known to us. Especially in fruits and nuts the Chinese mpire proves to be very rich, and as the similarity in soil and cliate between the native habitat of these products and certain areas f the United States is close the possibility of introducing these new orms for direct cultivation and for breeding work is most promising.

Respectfully,

WM. A. TAYLOR,
Acting Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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AGRICULTURAL EXPLORATIONS IN THE FRUIT AND NUT ORCHARDS OF CHINA.

INTRODUCTION.

The Chinese as a race are great lovers of fruits, and to satisfy their taste they grow these wherever there is a chance to do so. They understand the arts of grafting, budding, and layering; and although they are far less successful in their attempts to originate new varieties they are able to preserve those that have been secured. But as with crops in general so with fruits; particular districts are often characterized by peculiar kinds, and it frequently happens that a certain variety of fruit is found only in a single locality. This can be explained by the fact that certain varieties have apparently developed from seed obtained locally, and on account of the lack of skill in transplanting trees such varieties have never been successfully introduced into other localities. However, when one asks about these things one is generally told that certain fruits do not do well in other sections; that even if successfully transplanted they lose vigor or the fruits never acquire the right flavor, etc.

Another strange thing is that the Chinese never prune their fruit trees, although the trees grow dense and their branches interweave. When the branches become heavily loaded with fruit they are propped up or tied with straw rope. The only fruit which is really scientifically pruned is the grape; but here it is apparently a case of absolute necessity—no pruning, no fruit.

In transplanting, however, the cutting back of roots is carried to excess, and this is one of the reasons why tree planting in China is considered such a hazardous undertaking.

What is lacking, however, in the care of the trees is made up by the excellent care bestowed upon the soil. All orchards are cultivated except those of the jujube, which do not need it, but even these are kept free from weeds. The custom is to plow the orchards before the winter sets in, then to let the ground lie rough during that season, to plow it again in the spring, and to harrow and cultivate whenever the ground needs it, so as to conserve the subsoil moisture. Manuring is not much resorted to for fruit trees, as fertilizers of all kinds are too scarce; but crops are often grown between the trees, and perhaps the trees obtain extra nourishment from the manure supplied to these crops.

Of insecticides little is known. In some districts the bark of fruit trees is scraped scrupulously clean every winter. The trunks of peach trees are often whitewashed, apparently to kill the insects in the bark. Some fruit growers clean the trunks of their trees every year by applying a bundle of burning straw to them at the approach of spring. Of spraying, however, nothing is known. It is a good thing that there are so many parasites in China which prey upon scale and other insects; for if it were not for them, fruit growing would be almost impossible.

A peculiarity of Chinese taste is that the race as a whole does not care for soft fruits. One may even see high-class Chinese ladies selecting hard apricots from a basket containing a mixture of ripe and green ones and relishing the crunching of the hard fruit between their teeth. At dinner parties, fine-looking but extremely hard pears are served and are keenly relished by the most highly cultured Chinese. For this reason one finds that although raspberries, red currants, gooseberries, and various other small fruits grow wild in the mountains, one never sees them cultivated, and the fruit on these wild bushes is only sparingly picked.

PERSIMMONS.[a]

CHINESE NAME, "Shi tze."

The persimmon (*Diospyros kaki*) is one of the most important tree fruits in northern China. Certain valleys are entirely given over to its cultivation, and the revenue derived from the sale of the fruit often forms the main source of income for certain districts. For instance, in the small village of Tai-dja-tchwang, near the large city of Pautingfu, Chihli Province, the writer was assured in January, 1908, that the persimmon crop of the previous autumn had brought in about 10,000 Mexican dollars, an amount which, though seemingly insignificant to us, is really a very large item in a small village in China. The most favored location for a persimmon orchard is at the foot of a hill or a mountain with a southern or eastern exposure, where the land consists of a warm decomposed granite soil that will allow the water to drain off easily and yet will retain enough to prevent the trees from suffering in case a drought should occur.

Trees are generally planted from 20 to 30 feet apart, and, as they are not fast growing, peaches and bush cherries are often grown between them for the first dozen years or so. When, however, the persimmons need the space, these secondary plantings are taken out

[a] In the opinion of the writer the persimmons of northern China constitute a different group of these fruits from the various forms of *Diospyros kaki* found in Japan, but as *D. kaki* is so exceedingly variable it may be a very difficult matter to assign different varieties to well-defined groups.

FIG. 1.—A THRIFTY PERSIMMON ORCHARD IN THE MING TOMBS VALLEY, NORTH OF PEKING.

Fruit pickers are sorting the fruit.

FIG. 2.—A NEAR VIEW OF SOME HEAVILY LOADED BRANCHES OF THE TAMOPAN PERSIMMON, A LARGE, SEEDLESS, NONASTRINGENT VARIETY.

Introduction Nos. 16912, 16913, 16921, 22350, 22362, and 22365.

nd the soil is kept free from weeds and cultivated regularly. (See l. I, figs. 1 and 2.)

All the persimmons in northern China are ring budded or grafted pon a species growing wild in the mountains that bears small black uit full of seeds. The ordinary Chinese name for this wild persimon is "Ghae tsao," meaning black date, and statements have ppeared in several papers that the Chinese use a black date—that is, jujube—as stock for their persimmons. It is, however, an indisutable fact that the stock used in northern China is the *Diospyros tus* (fig. 1). In central China probably ther species are used, mong which is at least ne which has not yet een identified. (See Pl. III, fig. 1.)

FIG. 1.—The trunk of a persimmon tree more than a century old in a temple courtyard near Talanfu, Shantung Province, China. Note the clear division between the stock (*Diospyros lotus*) and the graft (*D. kaki*).

ULTIVATED VARIETIES.

Many different varieties of persimmons are grown in China, varying in size, color, productivity, etc. Of those that came under the writer's notice there is one that stands out above all others in excellent qualities. The fruit of this particular variety has a bright orange-red color, grows to a large size, measuring from 3 to 5 inches in diameter and sometimes weighing more than a pound. It is perfectly seedless, is not astringent, and can be eaten even when green and hard. It stands shipping remarkably well. The fruit is of a peculiar shape, having an equatorial constriction, which makes it look as if two fruits had been joined, or, to use a more terse expression, as if somebody had sat upon it (fig. 2). The trees are very thrifty growers when once thoroughly established. They reach a height of from 30 to 50 feet, and though the young branches are very erect the older ones bend down a good deal because of the great weight of the fruit. The trees seem to bear very heavy crops in some years, while

in other years the harvest is small. A drawback of a large crop is that the great weight of the fruit causes the large limbs to snap off unless they are propped or tied up. This, therefore, has to be done regularly. It seems that when the trees of this variety reach the age of 40 or 50 years they begin to decline in vigor; still, here and there old specimens may be seen that are near the century mark.

These large persimmons are mostly used when fresh. Foreigners in China are fond of eating them with a spoon, and after being kept in a cool place for some hours the fruit is very refreshing. They can be eaten while still hard, like apples. By careful handling and by keeping the persimmons at a low temperature they can be preserved for several months. To keep them through the winter the Chinese pile them in heaps, let them freeze thoroughly, and keep them frozen until they are needed. When wanted, they are simply put into a vessel with cold water to be thawed slowly, and then they are as good as when freshly picked. They can also be eaten

FIG. 2.—Four seedless Tamopan persimmons. Note the peculiar flattened shape of this fruit. Introduction Nos. 16912, 16913, 16921, 22350, 22362, and 22365.

when slightly frozen, like sherbet, and occasionally they are quite acceptable in that condition.

The variety described here is called by the Chinese "Ta shi tze," meaning big persimmon, or "Ta mo pan shi tze," meaning big grindstone persimmon, on account of its large size and flattened shape (fig. 2; Pl. II).. An abbreviation of the last, namely, Tamopan, has been suggested by the pomologists of the United States Department of Agriculture as a suitable name for this variety in the United States. (S. P. I. Nos. 16912, 16913, 16921, 22350, 22362, and 22365).[a]

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[a] The S. P. I. numbers mentioned in this bulletin refer to the numbers assigned by the Office of Foreign Seed and Plant Introduction to seeds and plants received from foreign countries and distributed with a view to determine their adaptability to conditions in the United States. For detailed information the reader is referred to the series of publications known as Inventories of Seeds and Plants Imported, of which 20 have been issued up to the present time.

TAMOPAN PERSIMMON.

A seedless variety containing so little tannin while hard that it may be eaten like an apple. Scions introduced in 1905 produced this fruit in Fayetteville, N. C., in 1910. (Natural size.)

Another variety, called "Shau mo pan shi tze," or small grindstone persimmon, resembles the first in every respect except as to the size of the fruit, which is smaller, being from 2 to 3 inches in diameter. For this reason the variety is not very generally planted. (S. P. I. No. 22366.)

Another kind, called "Siang shi tze," or sweet persimmon, is extremely rare; in fact, there seems to be only one tree of it, growing in an old temple yard in the Pang Mountains, east of Peking. The fruit is flat, but has no equatorial constriction. It also has seeds, generally from three to six. The skin is so tender that the fruit can not be shipped well unless frozen hard. It makes up for these defects by being particularly sweet and fresh in flavor. (S. P. I. Nos. 21910 and 22597.)

Another variety is called the "Lien hua shi tze," or lotus-flower persimmon (fig. 3). The appearance of the fruit of this variety is

FIG. 3.—Seedless persimmons, showing their remarkable shape. This variety is called "Lien hua shi tze," or lotus-flower persimmon. Introduction Nos. 16910 and 22367.

very peculiar. It is not large, only 2 inches in diameter, and bears besides the equatorial constriction two cross furrows, varying in depth in different fruits. Sometimes the incisions are so deep as to divide the top of the fruit into four lobes, resembling a coarse, waxy flower; hence, perhaps, the name lotus-flower persimmon. At other times, however, the incisions are so slight as merely to make the fruit appear undulated. The fruit is seedless and of a bright orange-red color. The flavor is not as fine, however, as that of the larger varieties mentioned before. The trees have the peculiarity of making a big warty growth where they have been united to the wild stock, and can always be recognized by that means.

The trees of this variety grow to a greater size than the other kinds, being from 60 to 80 feet tall, with heavy trunks. (See Pl. III, fig. 2.) They also live to a much greater age. In general they seem to be heavier bearers, but the fruit is several weeks later in ripening than

that of the larger kinds. They have the habit of dropping their leaves before the fruit is entirely ripe, and then a large tree heavily laden with bright-orange fruit is one of the most beautiful objects in an autumn landscape. (S. P. I. Nos. 16910 and 22367.)[a]

Another variety bearing small fruit of a yellow color, which contains seeds, is called "New sien shi tze." The tree is a slow grower and has a whitish bark. It is a rare local variety, near Pautingfu, Chihli Province. (S. P. I. No. 22368.)

Another variety of small size, oblong shape, and scarlet color, containing seeds, and called "Whoe shi tze," or fire persimmon, comes from the same locality. (S. P. I. No. 22369.)

In the Provinces of Shantung, Shansi, Shensi, Honan, and Chekiang there are many other varieties of persimmons that are still waiting to be introduced.

Some of the less juicy varieties are used extensively in the manufacture of dried persimmons. This dried fruit closely resembles figs in appearance and is of an excellent flavor (fig. 4). It can be eaten raw or stewed, like dried peaches or apricots. Compote can be made from it and is very wholesome. It is very likely that new industries could be built up in those sections of our Southwestern States where these dry-fruited persimmons succeed well.

FIG. 4.—Large dried persimmons, said to have come from northern Honan, China. They are an excellent dried fruit, as extensively used in China as the dried fig is in America. Often eaten stewed like dried peaches or apricots.

The writer found a few specimens of apparently the true *Diospyros kaki* in a copse near the Tai ching kong temple, Laushan district, eastern Shantung. The trees look exactly like the cultivated *D. kaki*, but the fruit is greenish yellow and of an unpleasant flavor. It is the size of a small plum and the seeds are imperfect. The trees are very rare, and were seen only once. The fact that the priests call them the "Shan shi tze," or wild persimmon, may be an indication of their being the prototype from which the cultivated strains of persimmons, in northern China at least, have been derived.

[a] This variety was apparently described by Carriere as *Diospyros costata* in the Revue Horticole, 1870, p. 132, also 1871, p. 410, where a colored drawing of the fruit is given. It seems, however, that the Costata variety of kaki of the American trade is quite a different variety, being of a pointed shape and only very slightly furrowed.

FIG. 1.—A GROVE OF PERSIMMON TREES NEAR HANGCHOW, CHEKIANG PROVINCE, CENTRAL CHINA, GRAFTED ON THE WHITE-BARKED VARIETY OF STOCK.

FIG. 2.—A LARGE SPECIMEN OF THE LOTUS-FLOWER PERSIMMON TREE AT TAIDJATSOA, CHIHLI PROVINCE, CHINA.

Introduction Nos. 16910 and 22367.

THE WILD PERSIMMON.

[CHINESE NAME, "Ghae tsao," meaning black date.]

The wild persimmon (*Diospyros lotus*), upon which the natives of northern China bud and graft all their cultivated varieties, grows wild here and there in the mountains of northern China (fig. 5). In its native haunts it seems to love protected rocky situations in ravines along small mountain streams. The trees do not grow large; sometimes they are more in the nature of a big shrub. When given space and good soil, however, they develop into good-sized trees with

FIG. 5.—The wild persimmon tree (*Diospyros lotus*) in its native habitat in the mountains near Changli, Chihli Province, China. This tree is ordinarily used as a stock for the large-fruited edible persimmon. Introduction Nos. 17906 and 17907.

dense heads of dark-green foliage. Old trees also have a very dark-colored trunk which is deeply grooved and furrowed (fig. 6).

It is a most productive bearer, being literally covered in the autumn with small blackish fruits the size of large cherries. The fruits are edible when soft or after a frost, but there is very little flesh to them, as they contain from three to five rather large seeds. Children are very fond of them, and a tree of this variety in a yard will certainly be worth its space.

In China, where everything is of value, this fruit is sold in large quantities, especially in the neighborhood of Changli, Chihli Province,

and travelers passing through on the railroad from Peking to Mukden in the fall of the year are certain to see boys and men coming to the train and offering baskets of these small persimmons, together with walnuts, grapes, chestnuts, peanuts, and other natural delicacies.

In their wild state the trees vary considerably in productiveness, size, and color of the fruit. Near Changli there are a few trees that have decidedly elongated berries, covered with a bluish bloom and very sweet to the taste. In the Pangshan district there are one or two trees bearing globular fruit, which is perfectly seedless; and in the mountains southwest of Pautingfu, small, yellow-fruited varieties are occasionally found.

FIG. 6.—The trunk of a large specimen of the wild persimmon tree (*Diospyros lotus*), showing its black bark with deep irregular grooves.

As a stock, however, this persimmon may give to its grafted host a much longer life than the native American persimmon seems to be able to, for in China all the cultivated persimmons grow much older than they do in America. Of some varieties there, one finds trees grafted on this *D. lotus* that are centuries old and still very productive. (See fig. 1.) (S. P. I. Nos. 17173, 17905 to 17907, 18266, 18599, 19395, 22370, and 22599.)

PEACHES.

[CHINESE NAME, "Tau" and numerous variations.]

CULTIVATED VARIETIES.

As is well known, China is supposed to be the original home of the peach (*Amygdalus persica*). Whether this is correct has not been settled, for peaches have been found wild in the southern Himalayas near Mussuri, according to Royle, and in the province of Ghilan in

Persia, according to Buhse;[a] and the writer has been assured by native Persians and by travelers that small hard peaches occur wild in the mountains of northern Persia. But the question of whether or not the peach came from China we shall not raise here. So far as we know at present, three important strains of peaches have been developed in China, i. e., the Chinese Cling group, the Honey group, and the Peento group. That these groups have proved more successful in the southern portions of the United States than the varieties introduced from Europe is also certain, and that some of our most important commercial varieties to-day are wholly or partly of Chinese origin has been proved indisputably.[b]

The Chinese Cling group reaches its greatest perfection in those parts of China where the summer is hot and fairly dry and the winter moderately cold and dry. The Honey group is to be found mainly in the more southern and central parts, where the summers are hot and humid, while the winters are mild and wet. The last group, the "peen" peaches, apparently thrives everywhere, from the extreme south to the north; but it is the least grown of all the peaches in China, and it is only in the extreme south where the better, larger varieties of peaches fail that the little Peen peaches are cultivated somewhat extensively.

In China the thriftiest and healthiest peach trees are always seen at the foot of a mountain or a hill, growing in decomposed rocky or sandy soil, and it is in such locations also that the fruit has the finest flavor. In the neighborhood of large cities, like Shanghai, one finds peaches grown on rather low, rich land, but the trees have so many diseases to battle with and the fruit is so watery that one clearly sees that such places are not congenial to the habits of the peach.

In general, a Chinese peach orchard contains many different varieties. Seedlings and budded trees are mixed in an irregular planting. Pruning is not resorted to, but the soil is kept in a high state of cultivation so as to minimize the danger of the trees suffering from a lack of sufficient moisture. In case the season is very dry and water is available, the Chinese often irrigate their trees, for it gives them much larger fruit.

As to the variation of peaches in China, it is as great as, if not greater than, anywhere else. Of the Chinese Cling group, there are some most excellent varieties to be found in northern China. The best of them all is the "Fei tau," or Fei peach (see Pl. IV, fig. 1), Feitcheng

[a] Hehn, Victor. Kulturpflanzen und Hausthiere, in ihrem Übergang aus Asien, etc.

[b] Powell, G. Harold. The Chinese Cling Group of Peaches. Bulletin 54, Delaware College Agricultural Experiment Station.

being the name of a village where the orchards are located. These peaches grow to a large size, often weighing over 1 pound apiece, and are of a soft, pale-yellowish color externally, with a slight blush on one side. The meat is white except near the stone, where it is slightly red. The fruit is a clingstone with a very large, pointed stone. The skin is very downy. The fruit ripens in the early and middle part of October and has an excellent flavor, being sweet and aromatic. It possesses extraordinary keeping and shipping qualities, keeping until February if wrapped in soft tissue paper. Its shipping qualities are such that it is carried in baskets, slung on poles across the shoulders of coolies, from Feitcheng to Peking, a journey of eight days on foot. So famous is this peach that it is sent every year as a tribute or present to the imperial court at Peking; and even right on the spot where this fruit grows the most perfect specimens retail at from 10 to 15 cents apiece in Mexican money, a price which is about two-thirds that of the average daily wages of the Chinese field laborer.

Another fine variety of peach grows near Hsinchow, south of Pautingfu, in the Chihli Province. The writer has seen specimens of this peach in Tientsin that were fully as large as good-sized navel oranges. They are of a pale, whitish-green color, with almost no blush, and very juicy and sweet, though not aromatic like the Fei peach. They are clingstones, the seed being medium large. They are not very downy, and ripen toward the end of October. They are exported to all the large cities of northern China, and can rarely be purchased in the open markets, as they are apparently nearly always supplied to private customers.

Another variety, found near Shanghai, is the "Tsu mau tau," a large fruit with whitish meat, changing to red near the stone, something like our Chinese Cling.

There are several strains of the "Hong tau," or red peach, growing in the Chekiang, Chihli, Shantung, and Shansi provinces, and even in Manchuria. Some of these peaches are blood red and when cut through look more like a beet root than anything else. One variety in Shansi is even called the "Rho tau," or beef peach, so much does it resemble meat. These, so far as has been observed, are not so sweet as the Peento group of peaches.

Of the Honey peaches there are also several varieties in China. In the Shantung Province, especially, there seem to be some very fine types. One which the writer ate in Taingtau was a large, white-meated freestone of a very pronounced Honey-type shape, called "Yang tau" by the natives.

Of the flat or Peen peaches there are several varieties. Some thrive in the moist southern regions of the Empire, others are to be

FIG. 1.—VIEW IN AN ORCHARD OF THE FAMOUS FEI PEACHES AT FEITCHENG, SHANTUNG PROVINCE, CHINA.

FIG. 2.—A LARGE SPECIMEN OF A CHINESE JUJUBE TREE, CALLED THE "MU SHING HONG TSAO," OR POINTED JUJUBE, AT TSINGYUENHSIEN, SHANSI PROVINCE, CHINA.

found even at the edge of Manchuria. The writer has noticed greenish, red, yellowish, and white types, varying a good deal in size and appearance.

In the Chekiang Province there is a red flat peach which ripens in June and is called "Hong peento," or red flat peach. A white variety occurs in the neighborhood of Shanghai, bearing the name "Pak peento," meaning white flat peach. In the Shantung Province there are some excellent sweet flat peaches. Near Kiaochou one variety is called "Pai pien tau" and is deliciously sweet and juicy. A yellowish variety coming from central Shantung is also very fine. It is called "Huang peento," or yellow flat peach.

There are several forms of peaches in China that are intermediate between the different groups and can not be assigned to classes by themselves.

How far the peaches of northern China may make it possible for us to extend the peach belt northward by using them in hybridization is a question that might be well worth consideration. In the city of Kirin, Manchuria, where the thermometer sometimes drops to $-40°$ F., there grows a small-fruited variety in a temple garden; and Prof. N. E. Hansen, of the South Dakota State College of Agriculture, has stated that rumors reached him on his last trip through Siberia of peaches growing in northeastern Mongolia, where the winters are very severe and very little or no snow covers the ground at that season.

One great difficulty in shipping bud wood of peaches is the fact that it does not travel very well. On the long journey over sea and land from China to America the buds become spoiled, although the wood may remain green and healthy. Owing in part to this fact, many excellent varieties of Chinese peaches have not as yet been successfully introduced.

NECTARINES.

Nectarines (*Amygdalus persica nectarina*) are apparently very rare in China, as the writer heard of them only a few times. Bud wood was obtained but once, and that was in Kwangning, Manchuria, where this fruit is called "Ta hsing-mei."

THE ORIGINAL WILD PEACH.

[CHINESE NAME, "Shan tau shu," meaning wild peach tree.]

In connection with the cultivated peaches a few words about a peculiar wild Amygdalus will not be out of place. This species, *Amygdalus davidiana*, was observed growing wild on the rocky south slopes of mountains in the neighborhood of Peking, Jehol, and in the neighborhood of Taitchow, Shansi Province (fig. 7). The plants in the wild state always grow shrubby and are from a few feet to 10

or 12 feet high; but when planted in gardens as ornamentals, as one often sees them in Peking, Tientsin, Chinanfu, etc., they reach a height of 30 to 40 feet and form a single trunk, sometimes over a foot in diameter (see Pl. V, fig. 1). The cultivated plants vary a good deal in the color of their flowers, which ranges from white to dark rose. The flowering period lasts but a very short time, but as the trees bear graceful dark-green foliage after their flowering they are quite ornamental.

The greatest value, however, that these wild peaches have for us is not so much in their ornamental appearance as in their use as a stock for almost all members of the stone-fruit group. The Chinese graft and bud upon them not only peaches but plums, "bush cherries" (*Prunus tomentosa*), flowering plums, and cherries, and all of these thrive upon this stock. They are also remarkably drought resistant, and as far as our preliminary experiments show they thrive equally well at Ames, Iowa, and at San Antonio, Tex. From the nature of the tree it will do especially well in those sections of the United States where there is only a limited summer rainfall and where winter temperatures do not fall too low.

FIG. 7.—A tree of the wild peach (*Amygdalus davidiana*) growing among rocks in the mountains near Fangshan, Chihli Province, China. This variety is commonly used as a stock in China. Introduction No. 22009.

The kernels of these wild peaches are used to flavor confectionery and some special dishes, but as they are full of prussic acid only very small quantities are used. The stones themselves are often made into rosaries, which the Buddhist priests use in their worship. Being deeply and irregularly grooved they are very artistic when cleaned and polished. (S. P. I. Nos. 17470, 17729 to 17731, 18262, 18595, 21227, 21908, and 22009.)

APRICOTS.

[CHINESE NAME, "Hsing," and other names.]

The apricot (*Prunus armeniaca*) is found in a wild state in many places in northern China, Manchuria, and northern Korea, and therefore it is no surprise to find it growing as a fruit tree on a large

FIG. 1.—THE WILD PEACH (AMYGDALUS DAVIDIANA) COMMONLY USED AS A STOCK FOR STONE FRUITS.

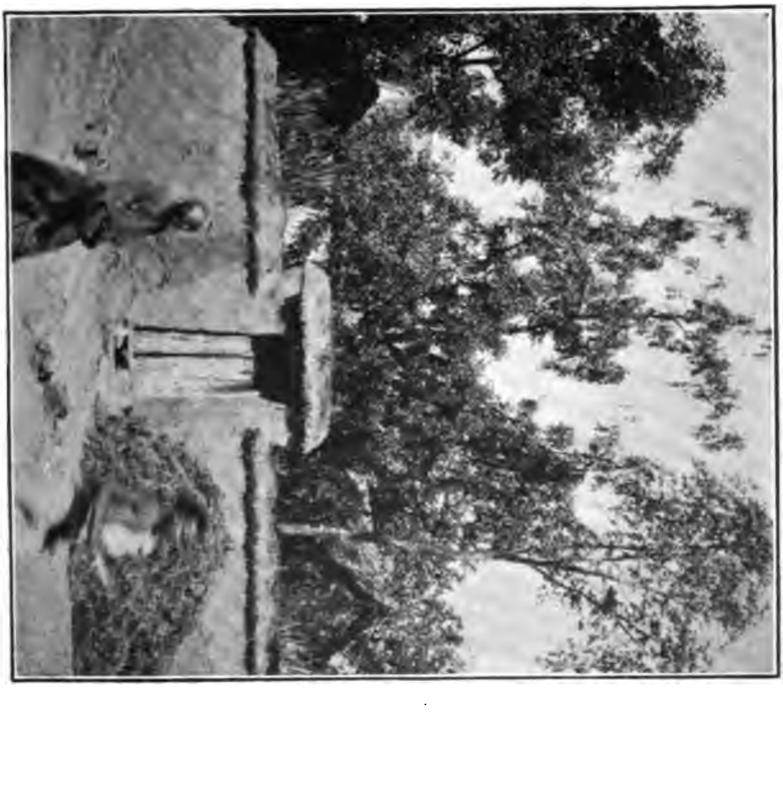

FIG. 2.—A HEAVILY LOADED TSAO OR CHINESE JUJUBE TREE (ZIZYPHUS SATIVA) IN A COMPOUND NEAR NINYANG, SHANTUNG PROVINCE, CHINA.

scale. There are red, orange, yellow, red-and-white, and white-spotted varieties in cultivation. In size there is also great variation.

The Chinese bud and graft their apricots upon seedling apricot stock and also upon the wild peach (*Amygdalus davidiana*). The trees generally are not grown in regular orchards, but in small lots of a few trees each. A decomposed granite or gravelly soil is preferred, and the trees thrive especially well on terraces on the mountain sides.

The Shantung Province is famous for its fine apricots, and there are several varieties there that are well worth introducing. There is also a strain of apricots in the Chihli Province that has sweet edible kernels. These kernels are sold as almonds and have created the impression that the almond occurs in China. However, I have never seen a single true almond tree in China, although I believe that in certain sections they would grow to perfection.

Apricots are nearly always eaten in China when not quite ripe, even small, hard, green fruit being eagerly eaten in early summer. Some of the less juicy and more acid varieties are cut in half and dried and sold during the winter months as delicacies. The Chinese say that a tea made from these apricots is very wholesome, purifying the blood and being laxative. Various compotes are made from the ripe and partly ripe fruit in which sugar and honey play a considerable part. Some of these delicacies are very good. (S. P. I. Nos. 17152, 17154, 20067, 20072, 22344, 22437, 22444 to 22446, and 22580.)

WILD APRICOTS OF NORTHERN CHINA, MANCHURIA, EASTERN SIBERIA, AND NORTHERN KOREA.

It has been proved that the apricot is able to stand far more cold and drought than is at present supposed. One finds the shrubby wild apricots all over the mountains of northern China and southern Manchuria, and forms which develop into regular trees occur in northern Korea, northern Manchuria, and eastern Siberia. The writer observed giant apricot trees growing in a mountain ravine near Tchangsong in northern Korea, fully 40 feet tall, the trunk of one measuring 10 feet in circumference. The fruit, though, is small and worthless, but as a stock plant and for hybridization purposes it might be of very great value.

That in the future large sections of the United States will be able to grow apricots where now there are none can be readily shown, for some of these Asiatic apricots have proved to be hardy at Boston, Mass., and even in the trying climate of Wisconsin. At the present time there is a large specimen of a central Asian apricot tree growing in the grounds of the State Agricultural Experiment Station at

Madison, Wis., and it has been thriving there for at least thirty years, without having suffered in the least from the low temperatures occasionally experienced there. (S. P. I. Nos. 16917, 18290, 19489, and 20068 to 20071.)

PLUMS.

The plum (*Prunus* sp.) is a fruit which is not very highly esteemed in China. Whether this is on account of its softness and its nonshipping qualities or whether because of its sourness we do not know, but plums do not form a big item in the fruit production of China.

The Shantung Province, which is the finest fruit-growing region of northern China, supplies the best plums, large red and yellow ones being even exported to various coast towns. In Peking one is able to obtain plums of one variety as late as the middle of November. This particular plum is yellowish green, with a slight blush on one side, and is of quite a sweet flavor. It is a freestone. (S. P. I. No. 17913.) There are a few other varieties grown in the neighborhood of Peking, but the writer saw the trees only when the fruit was gone and therefore could not obtain samples. Plums are grown in several places in Manchuria, as in Kwangning, Liaoyang, and Kirin. In this last place there is a red-fruited variety of medium size, not very fine eating, but excellent for preserves. As the cold gets very intense in Kirin, these plums may prove to be valuable in breeding. (S. P. I. No. 20241.)

The farthest north, however, that the writer found plums was in Khabarovsk. There, in the garden of Gen. M. Vedenski, he obtained bud wood of a yellow plum of good flavor that is able to withstand, unprotected, winter temperatures of $-45°$ F. (S. P. I. No. 19605.)

In central China are found peculiar plums. One apparently belongs to the species *Prunus triflora*. Another kind produces green fruit which is exported extensively, preserved in sirup or dried. It is of a beautiful green color and is much used in confectionery. The local name is "Shing mae." It is probably a form of *Prunus mume*.

There is another plum which has the appearance of an apricot, but is sour like the plum. It is very fragrant, has a downy, dull-yellow skin, and is a clingstone. The stones are peculiarly grooved, looking like wild-almond stones. This plum may be a hybrid between an apricot and a peach, or perhaps a new kind altogether.

In the Shantung Province there grows a plumcot, called by the Chinese "Lishing," which means plum-apricot. The fruit is large, red, and very sweet and aromatic. There seem to be about three known varieties of it, and the best ones are said to come from the neighborhood of Chingchowfu, Shantung Province. The few trees of this remarkable fruit that were seen by the writer had all the appearance

in leaves, buds, branches, general habits, etc., of hybrids between the apricot and the plum. They are all grafted upon seedling plum stock.

A species of very hardy wild plum occurs in northern Korea and eastern Siberia. It is tall and shrubby in growth, is found in high meadows or among bowlders, and bears large quantities of very sour blue plums of medium size. (S. P. I. Nos. 20073 and 20343.)

CHERRIES.

[CHINESE NAME, "Ying tao'rh."]

The real sweet cherries (*Prunus avium*) do not seem to occur in northern and eastern China, but instead of them they have in the moist, mild-wintered regions of the Yangtze Valley the ordinary Chinese sour cherries (*Prunus pseudo-cerasus*), the fruit of which is rather small and generally sour but very early.

FIG. 8.—A heavily loaded branch of a large-fruited variety of the Chinese "bush cherry" (*Prunus tomentosa*) in a garden in Fongwhangcheng, Manchuria. Introduction Nos. 16918, 17732, 17733, 20075, 20240, 20287, 20288, and 21924.

An example of this earliness is found in the fact that a scion of one of these cherries (a sweet variety) was grafted in the spring of 1906 upon an ordinary Mazzard cherry in the United States Plant Introduction Garden at Chico, Cal., and the following year it bore fruit which was half grown on April 12, at a time when other cherries were just in bloom. (S. P. I. No. 18587.)

The most common cherries in northern China are the "bush cherries" (*Prunus tomentosa*) (fig. 8). These grow wild in the mountains of northern China, Manchuria, and Korea, and are found in dry, rocky places. In a wild state they are densely branched shrubs, bearing very small red fruit; the leaves are very tomentose. When cultivated, however, the plants become less dense in growth, the leaves lose their hairiness to a great extent, and the fruit becomes larger. There are varieties having fruit large enough to be worth consideration as a dessert fruit for localities where our ordinary

cherries fail. The Rocky Mountain regions and the regions farther south should be excellent for these bush cherries.

In propagating these plants the Chinese use three methods; i. e., layering, division, and budding upon the wild peach (*Amygdalus davidiana*). The first two methods are but sparingly employed on account of the great difficulties experienced in northern China in transplanting small-rooted plants, either in autumn or in spring, for both seasons are very dry; the last rains fall in September and the first rains often do not come until late in June. They find, therefore, that the best way to multiply these bush cherries is to bud or graft them upon the wild peach, which seems to be a very congenial stock and upon which they make an even faster growth than when left on their own roots.

These Chinese bush cherries prefer a decomposed rocky soil, but do well in almost all other soils when properly cared for. In the garden of Mr. and Mrs. Lykkegaard, of the Danish Mission in Fongwhangcheng, Manchuria, they thrive even under the shade of tall elms, and when seen on June 30, 1906, bore masses of fruit. The preserves which Mrs. Lykkegaard gave the writer to sample were excellent. It is thought that this cherry has a future before it in America. (S. P. I. Nos. 16918, 17732, 17733, 20075, 20240, 20287, 20288, and 21924.)

There is also another cherry sparingly grown in northern China, a small tree or large shrub which has leaves and fruits more like our ordinary cherries, but which grows very dense and seems to be far less hardy than the bush cherries. It is probably the *Prunus pauciflora* of Bunge. It is sparingly cultivated in the neighborhood of Peking, but in the protected mountain valleys of the coast region of the Shantung Province several orchards of it were seen. It is not at all a common fruit tree. (S. P. I. No. 22361.)

There is also a wild dwarf cherry or plum (perhaps *Prunus humilis*) growing in northern China, Manchuria, Korea, and eastern Siberia. The shrubs grow from 1 to 3 feet high, occur on stony and sandy soils, and bear multitudes of scarlet fruits which are generally inedible on account of their sour and acrid properties. Some plants, however, produce slightly sweet fruit that can be eaten raw. The writer never cooked it but thinks that it would make good preserves. This dwarf cherry can very well be used as an ornament in gardens and rockeries. Its greatest value, however, lies in the fact that it can be utilized in breeding experiments. It may also become a fruiting shrub in those regions where fruit growing is now an impossibility. (S. P. I. Nos. 20076, 20085 to 20088 and 20342.)

PEARS.

[CHINESE NAME, "Li."]

CULTIVATED VARIETIES.

Next to the peach, the pear (*Pyrus chinensis*) is probably the most highly appreciated fruit of northern China. Numerous varieties are grown, but not all of them are fit to be introduced into our western lands as acquisitions, for many of them are but seedlings and produce worthless fruit.

The Chinese grow their pears for the greater part on terraced fields and patches in the mountains; but in some regions, as to the south of Peking, where the soil is sandy and is easily blown about, one finds whole orchards of good pears growing upon the plains.

There is a story current among the foreign residents in China that a certain newcomer was asked his opinion of the Chinese pears. "Well," he said, "it depends on what you eat them as; as turnips they are certainly fine, but as pears I would rather not express any opinion." This statement is true so far as the greater number of the Chinese pears is concerned, but there are a few very good ones in China that are well worth cultivation by western people.

The best pear of northern China is, in the opinion of the writer, the quince pear, or, in Chinese, "Ya kwam li." This pear attains a large size, often weighing more than one-half pound; has a somewhat warty, dull-yellow skin, looks and smells like a quince, and has flesh that is mellow, juicy, and aromatic. It is considered so good that it is served upon the tables of foreign hotels in Peking and Tientsin. These pears do not bear rough shipment very well, but when carefully handled they can be kept for the greater part of a year. The trees prefer a sandy soil and are of a spreading habit, so that they require a great deal of space. (S. P. I. Nos. 17724 and 21253.) There is also a smaller variety similar to this, which is not much grown, as the fruit does not bring so good a price as the large variety does. (S. P. I. No. 17725.)

The second-best pear is the so-called "Peking pear," or, in Chinese, "Pai li," meaning white pear. This pear is round like an apple, with a short peduncle, a waxy, yellowish-white color, and has mellow flesh of a sweet flavor, resembling that of our own pears very much. It ripens late and, being a poor keeper, disappears very quickly from the markets. There is some variation in the size of the fruit on different trees. Some are very small, others large, but in general this Pai li is rather a small-sized fruit. (S. P. I. Nos. 16916, 17723, and 22432.)

Another mellow pear of pale-yellow color and of medium size and good flavor is the "Pei soo li," a rare local kind grown in the neighborhood of Jehol. (S. P. I. No. 21928.)

There is also the "Ta suan li," meaning big sour pear, having a very short peduncle and persistent calyx. It is greenish yellow in color. It remains hard until spring, then becomes mellow and has a peculiar, agreeable, sour taste. It is excellent for making into preserves to be used with game or meat. This variety grows near Jehol, China. (S. P. I. No. 21929.)

Then there is the "Mien suan li," or mealy sour pear, which closely resembles the preceding variety and grows near Kwangning, Manchuria. (S. P. I. No. 20260.) Another sour variety, called the "Mo pan suan li," or grindstone sour pear, is similar to the first-mentioned variety. This kind grows in the city of Liaoyang, Manchuria. (S. P. I. No. 20248.)

Another mellow pear, with an agreeable tart flavor, is the "Guarr li," growing at Jehol, China. This variety is rather small, has a short peduncle, is of yellow color, and has a rosy-red blush on one side. (S. P. I. No. 21931.)

Besides all these mellow pears there are a great number of hard pears in China and, strange to say, the Chinese prefer these to the soft ones. The best of all the varieties of hard pears of northern China is the "Ya'rh li." This pear is of large size, of a clear, light-yellow color, has the real pear shape, with a very long peduncle and a nonpersistent calyx. The flesh, although hard, is very juicy and sweet, and foreigners come to like it as much as the natives do. The shipping and keeping qualities of this variety are excellent, and it is to be obtained in northern China throughout the whole winter. There is a good deal of variation in the size and flavor of the fruit, caused by the difference in the trees or by localities, but on the whole this "Ya'rh li" is a fine large pear, well worthy of being introduced. (S. P. I. Nos. 16924, 17178, 17726, 20233, 20234, 20256, 22438, and 22442.)

Another pear, of very large size, ocher-yellow in color, but with coarse flesh, is the "Ma ti huang li," or horseshoe pear. The writer found it growing in gardens in Liaoyang and Kwangning, in Manchuria. (S. P. I. Nos. 20247 and 20251.) Another kind, famous for its fruit, which is dried and put up in boxes, is the "Hsiang sui li," or fragrant water pear. It grows especially well in the city of Liaoyang, Manchuria, and every year a present of a number of boxes of these dried pears is made to the Emperor at Peking.[a] The trees are very vigorous growers, but apparently shy bearers. They can, however, stand a good deal of cold and grow even in and near Kwangchengtze, Manchuria. (S. P. I. Nos. 20232, 20245, and 20253.)

[a] See Hosie, Alexander, Manchuria.

Near Kwangning, Manchuria, one finds not only this variety but also another, called the "Huang hsiang sui li," or yellow fragrant water pear. (S. P. I. No. 20271.) Then there is the "Mi li," or honey pear, a local variety growing in the Pangshan district, Chihli Province, northern China. It is rather small, egg shaped, with a very long peduncle, a canary-yellow color, a hard flesh, but very juicy and sweet, and is a good keeper. (S. P. I. No. 21912.)

The "Ten li," a rare local variety at Jehol, is of medium size, of a dark canary-yellow color, hard fleshed, but juicy and very sweet. It also is a good keeper. (S. P. I. No. 21930.)

The pears of western Shansi, of the Kwohsien district, are famous for their extraordinary keeping qualities. The "Yoh li," or oil pear (fig. 9), for instance, can be kept for more than a year. This pear is round-oblong in shape, with a long peduncle, is of a straw-yellow color with a reddish cheek, very fragrant, and, although of hard flesh, is very juicy and sweet. These pears are covered with a

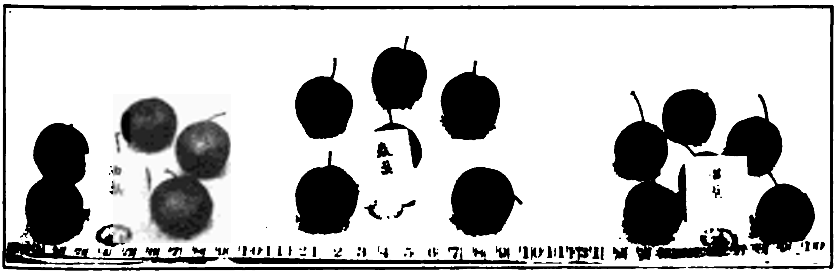

FIG. 9.—The best three varieties of pears of the Kwohsien district, Shansi Province, China. The group to the left is the "Yoh li," or oil pear; that in the center, the "Ben li," or furrowed pear; while the fruits to the extreme right are the "Huang li," or yellow pear.

fatty substance, which perhaps explains their keeping qualities and has given them their name, oil pear. The trees of this variety have a very spreading habit and grow to be very old, even near a century and a half.

A second one of these Kwohsien pears is the "Ben li," or furrowed pear (fig. 9). This is of medium size and apple shaped, with a long peduncle. It has four more or less deeply impressed furrows near the peduncle. It is a good keeper, but has not so fine a flavor as the "Yoh li." The trees of this variety grow with semi-erect branches and do not attain as great an age as the preceding variety.

The third good variety of this Kwohsien district is the "Huang li," or yellow pear (fig. 9). It is generally of large size, oblong in shape, with long peduncle, of a pale-yellow color, and fragrant; the flesh, although hard, is very juicy and sweet. It also is a good keeper. The trees have very erect branches.

In the Shantung Province there are some very large pears. The "O li" often weighs 1½ pounds, is green in color, and has hard flesh. The "Siu hua li" is a large yellow pear of the same province. This pear is so flat that the vertical diameter is only one-third of the horizontal, the shape making it look like a curiously flattened apple.

A pear of the Pangshan district, Chihli Province, called the "Ma li," or horse pear, is barrel shaped, with a long peduncle, of pale-straw color, and hard but juicy. It is a very good keeper and shipper. (S. P. I. No. 21914.)

There is a group of red pears in northern China, all of which are apple shaped and remarkable keepers and shippers. One found in the Poliping region, west of Peking, is called "Hong hsau li." (S. P. I. No. 22439.) Then there is the "Hong li," or red pear, of this group. Several varieties of it come from Tongchangdi, Shansi; Pangshan, Chihli; and Kwangning, Manchuria. (S. P. I. Nos. 20257 and 21911.) Another of these red pears is the "Hong bo li," from near Pautingfu, Chihli Province. (S. P. I. No. 22443.) Still another is the "Shui hong hsiau li," from Liaoyang, Manchuria. (S. P. I. No. 20244.)

All these pears are hard fleshed, of medium size, of slightly sour taste, and look so much like apples that one often has to examine them closely to detect the difference. There are also a number of mediocre pears in various places in northern China, like the "Bay li," from Kwangchengtze, the "Kuan hung hsian li," from Kwangning, Manchuria, which, we were informed, is grown only for the Emperor's use, and all the trees of which are known to the magistrate of the district. The "Liu yuea li," from Kwangning, Manchuria, needs to be kept for six months before it acquires the right flavor, while the "Ta yang li," from the same district, needs to be boxed for a month before it is in condition to eat. The "Chin tze li," from Kwangning, Manchuria, is said to have excellent keeping qualities. The "Yuan po li," the "Ta li," the "Yu chin li," the "Chang poa li," the "An li," the "Mien kuan li," the "Chin pai li," the "Ta ma li," the "Ping ding li," the "Ghua kai li," all from Kwangning, Manchuria, and the "Tang li," or russet pear, from the Pangshan district, Chihli Province, and from Kwangning, Manchuria, may be mentioned. The last two pears are apple shaped and have a russet color like the Japanese pears. They are good shippers and keepers, but the flesh is of a coarse texture.

Besides the varieties named there are scores of seedlings in almost every orchard that produce fruit of so little value that they bear no names. As a whole, however, some of these cultivated varieties of Chinese pears will in the future prove to be of very great value to the American fruit growers who will use them for breeding hardier, blight and scale resistant varieties, the more so, as we can point already to

our Kieffer, Le Conte, Garber, and some minor varieties which possess Chinese blood in a greater or less degree and which have made pear culture possible in sections of the United States where the European varieties have utterly failed.

WILD PEARS IN NORTHERN CHINA.

There are a few species of wild pears (Pyrus) in northern China which are of great importance to the Chinese and may become so to us. The true Chinese pear (*Pyrus chinensis*) is found growing sparingly in copses in mountain valleys in the Chihli and Shantung provinces. The writer always found these trees as isolated specimens. They are tall trees of open growth and bear small yellow fruit on very long peduncles. The calyx is deciduous. The leaves are few but large, long pointed, and are glossy green above and light green beneath. The trunks have a light-brown color; the bark comes off in strips and the trunks are fairly smooth. This type of tree has probably given rise to the hard-fleshed, yellow-fruited strain of pears, with deciduous calyxes, which is so commonly cultivated in northern China. This group prefers warm, sheltered nooks, and is not found in very cold or exposed localities. (S. P. I. No. 17176.)

There is another type of wild pear quite distinct from that mentioned above. This variety is found on the plains, at the foot of mountains, and here and there on the lower slopes of mountains and hills. It generally grows in clumps and even in large groves. The trees are densely headed and possess spiny branches. The fruit is small and flat, with a very short peduncle and a persistent calyx. It is greenish yellow in color and astringent and inedible before freezing, but after a heavy frost it becomes soft and yellow and has a slightly sour taste. The trees grow to large dimensions in favorable localities. At Shinglungshan, northeast of Peking, there are specimens that grow from 60 to 80 feet high and have trunks from 2 to 3 feet in diameter. The wood has a fine light-brown color and is utilized in the manufacture of printing blocks and wooden combs. The trunks are of a blackish color and, when old, deeply furrowed. This variety, or perhaps species, grows in the colder parts of northern China, in Manchuria, and eastern Siberia, and improved varieties are being grown as far north as Khabarovsk, where the mercury is frozen nearly every winter.

This species of pear has given rise, in all probability, to the mellow-fleshed pears of northern China; if not to all of them, certainly to the "Ta suan li," the "Mo pan suan li," and the "Guarr li," all three of which resemble very closely the wild type. (S. P. I. Nos. 17177, 19604, 20243, 20267, 20336, 20337, 21880, 21918, and 21923.)

Another type of pear, called the "Tang li," grows wild here and there in the Shantung Province. In characteristics it stands midway

between the two last-mentioned species. The trees are found as isolated specimens and look very much like the real *Pyrus chinensis*, but are of denser growth and have large, beautiful, glossy leaves, while the fruits are rather large, have medium-long peduncles and persistent calyxes, and are mealy when ripe. Their color is a rusty brown. A small group of pears, the "Tang li" group, has probably been derived from this strain of wild pears. (S. P. I. No. 21983.)

The last in the list of the wild pears in northern China is the *Pyrus betulaefolia*, or "Doh li." The fruit of this pear does not grow any larger than a good-sized green pea. It hangs in bunches, covering the whole tree, is brown in color, and does not become soft and edible until late in the fall. The trees generally do not grow very tall, but form extraordinarily dense heads of branches. One often finds well-developed specimens growing on the alkaline or sandy plains. They thrive equally well on cliffs and along streams, but they are then of a more shrubby nature. This pear is extensively used as a stock for cultivated varieties in those parts of northern China where the winter is not too severe. It stands alkali wonderfully well and will grow even in pure sand.

The Chinese claim that this pear is far easier to grow from cuttings than to raise from seed. I can not vouch for this statement, but I know that the people apparently always have some stock on hand, though it has often a wonderfully straggling habit. This pear may be of use to us as a shade and ornamental tree, being covered in the spring with an amazing quantity of flowers, followed by a multitude of small fruits, which hide among the dense mass of foliage. (S. P. I. Nos. 17727 and 21982.)

APPLES.

[CHINESE NAME, "Ping kua."]

CULTIVATED VARIETIES.

The apples (*Malus* spp.) of China are very inferior in flavor to the western kinds. In fact, the true apple, *Malus sylvestris*, does not do very well in eastern China, and beyond a few specimens in the gardens of foreign residents it seems to be unknown to the Chinese. In the Shantung Province and in some parts of Mongolia there are said to be native apples of superior flavor, but I never had the good fortune to come across them, unless it were some apples I tasted in the garden of the late Doctor Nevius, an American missionary in Chefoo, who introduced many kinds of western fruits into China.

The larger, whitish varieties of apples which the Chinese cultivate seem to belong to the *Malus prunifolia* group. The trees have a wide-branching growth; the leaves are tomentose, ovate, with rounded

ends and long petioles. The fruit though often attractive in appearance is soft, spongy in texture, and insipid in flavor. The trees do not grow in very cold and exposed regions and do not seem to be able to stand much drought.

Belonging to this group is the "Pai ping kua," or white apple, from the environs of Peking and Pautingfu. The fruit varies a good deal in size. It is much used for preserves. (S. P. I. Nos. 22371 and 22440.) Mention may be made of the "Hong teng ku," or red apple, from near Pautingfu (S. P. I. No. 22372), the "Sha hoa tze," a medium-sized apple of whitish color, with red cheeks, from Kwangchengtze, Manchuria (S. P. I. No. 20230), the "Ping kua" (S. P. I. No. 20280), and the "Pin tze" (S. P. I. No. 20277), from Kwangning, Manchuria, and the "Sa kua," from the Pangshan district, northern China, and Kwangning, Manchuria. The last is a flat apple, like the saucer peach. It has an insipid flavor and does not keep well. (S. P. I. Nos. 20276 and 21915.) The "Ly tze" is a sour red apple, also of a flat saucer-peach shape and a poor keeper. It is from the Pangshan district. (S. P. I. No. 21916.)

There is another group of apples in China, the trees of which are of large growth, the branches erect, the leaves pointed, very little tomentose, or even glossy. The fruit is small, mostly of a red color, and though often mealy is generally sour in flavor. This group stands more cold, drought, and privation than the first class. The trees thrive as far north as Khabarovsk, on the forty-fourth parallel of latitude. In all probability they have been derived by selection and perhaps hybridization from the wild crab apple (*Malus baccata*), which is abundant all over northern China, Manchuria, northern Korea, and eastern Siberia.

To this group belong the "Hua hong," a large red crab apple growing in Kwangchengtze, Manchuria (S. P. I. No. 20231), the "Gai tang," the fruit of which is as large as a good-sized cherry, dark red in color, with a bluish blush, and growing near Jehol, northern China (S. P. I. Nos. 21879 and 21927), and a variety called by the Russians "Reinetka," growing vigorously in Khabarovsk, Siberia, and probably the same as the "Hua hong." (S. P. I. No. 19603.)

THE WILD CRAB APPLE.

The Chinese in northern China and Manchuria and the Russians in Siberia graft all their apples on the Siberian crab apple (*Malus baccata*), which, as stated before, grows wild all over northeastern Asia. There is great variability in the size of the tree. Sometimes one finds a specimen on an exposed, dry mountain side, in appearance like a gnarled shrub, but bearing an abundance of fruit. Again, in good fertile spots one may see it as a tall tree from 40 to 50 feet high

and having a trunk a couple of feet in diameter. The productivity of these wild crabs is something marvelous. The little apples, about the size of small green peas, are eagerly collected by the Russians and the Chinese and are either eaten fresh, dried, or made into preserves.

From what the writer has seen of the hardships this wild crab apple is able to stand in its native haunts, it would seem that there are few places in the northern portions of the United States where it would not succeed. Even if it is not suitable as a fruit tree it is a fine ornamental plant, both when in bloom and when loaded with its thousands of little scarlet fruits. (S. P. I. Nos. 20137, 20237, 20238, 20339 to 20341, 21065, 21878, and 21922.)

QUINCES.

The quince (*Cydonia* sp.) most often seen for sale on fruit stands in China is the true Chinese quince, *Cydonia sinensis*, or in the native vernacular, "Mu kua." The trees are by no means common throughout northern China. One has to travel to central Shantung before finding them growing even sparingly in gardens, and it is only farther south that they are cultivated on a large scale for shipment. The fruit grows to an exceedingly large size, being sometimes even a foot long and weighing 10 pounds apiece. It is never eaten by the people of northern China, but is used by them exclusively for perfuming their rooms. The well-to-do classes have in the winter time a large bowl filled with the fruit and placed upon a table in a cool room, so that it perfumes the whole atmosphere with a delightful spicy aroma. Foreign residents, however, have found that these quinces make excellent sweetmeats, and they preserve them in various ways. The writer has tasted jellies and jams made from them that were unexcelled for fine, aromatic flavor. (S. P. I. No. 17954, under *Cydonia japonica*.)

There is also a variety of the Japan quince (*Cydonia japonica*, S. P. I. No. 22581) cultivated sparingly in the mountains near Peking. The fruit is small, of a greenish color, covered with a brown bloom, and very fragrant. It is called "Pei mu kua," and is also used for perfuming rooms, but mostly by the poorer classes, it being very much cheaper than the Chinese quince.

Another variety of the Japan quince is called "Mu li." Its fruit is larger than that of the preceding one, has a very spicy odor, and is used for the same purpose as the first two. (S. P. I. Nos. 18601 and 22629.)

In the Shantung Province there were also observed in a few temple yards cydonias that grow to be tall trees, from 30 to 40 feet in height, with a very smooth bark that comes off in strips. The leaves

are round-oblong, serrated, with very short petioles, glossy, dark green above and light green underneath. The fruit looks like the European quince. It is very woody and not edible, but it possesses a pleasing, spicy odor. The writer noticed two other varieties, one having round fruit and called "Hsau kua shu" (S. P. I. No. 21984), the other with oblong fruit, the "Mu li shu."

Here and there in central China, as in Hangchow and Soochow, the Chinese cultivate in earthen vessels a very uncommon dwarf form of *Cydonia japonica* var. *maulei*. It is called the "Lo hai tang," and seems to be used for ornamental purposes only. (S. P. I. No. 22984.)

HAWS.

[CHINESE NAMES, "Hong kua," "Suan dzao," and "San li hong."]

In northern China there are whole orchards of an edible haw (*Crataegus pinnatifida*). These trees have all been grafted. They are carefully cultivated and the fruit is harvested and shipped all over the land, very much, in fact, as apples are with us. (See fig. 10.) The fruit is of a bright-red color, fairly hard, and of an agreeable sour taste. There is considerable variation in the size of the fruit and its acidity, but the best kinds are as large as good-sized crab apples and are only slightly acid.

Haw fruits are extensively used in the manufacture of sweetmeats and preserves, and foreigners and natives are equally fond of them. In the foreign embassies in Peking one is served with cake that has preserved haw fruit as a filling. Foreign missionaries supply visitors with a kind of haw jelly, and the Chinese give a jar of haw preserves as a New Year's present. The fruit of a rather sour, dry-meated variety is sliced and dried and kept for winter use. In this form it is called "Suan dza." The Chinese make much use of it during the winter months for brewing a tea which they claim acts as a blood and system purifier. This dried fruit can also be stewed, and by the addition of sugar it makes a good compote, tasting not unlike apple preserve. It is one of the fruits that can be safely introduced into America and will not have to wait long to become popular.

Aside from its fruit it is a very handsome, ornamental tree, making a dense head of dark-green foliage, turning into gorgeous red and yellow in the fall. The height rarely exceeds 30 feet, and some varieties branch out almost at the ground, thus making them well suited for ornamental trees on lawns. (S. P. I. Nos. 17171, 17739, 17882, 17883, and 19405.)

The largest and best haw fruit comes from the Shantung Province. It is especially in the neighborhood of Taianfu that one finds remarkably large-fruited varieties, the trees of which are very productive.

There are many seedlings of this haw in cultivation which in general bear but small fruits, and these smaller ones are nearly always more acid than the larger varieties. This is an advantage in one way, for this acidity makes them an excellent substitute for cranberries, a fact which the American missionaries in the Shantung Province have learned to their advantage. Since this haw is a very hardy tree and can stand considerable drought and heat its fruit might take the place of cranberries in sections of the United States where the latter are hard to obtain at the present time, as anyone

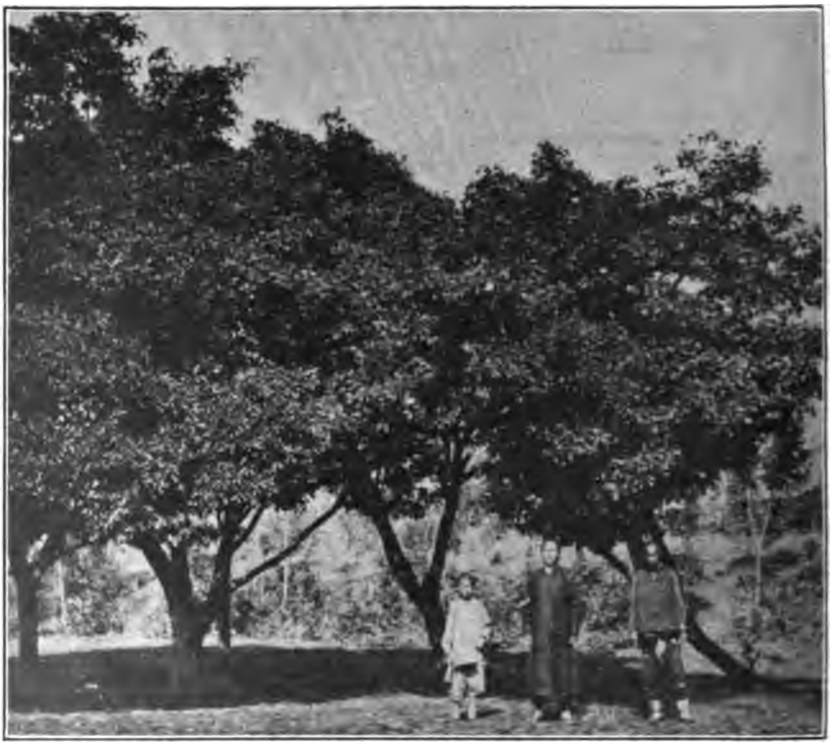

FIG. 10.—A group of trees of a large-fruited variety of the Chinese haw (*Crataegus pinnatifida*) near Changli, Chihli Province, China. The fruit of this variety is extensively employed in the preparation of marmalade and jelly. Introduction No. 17882.

could grow one or two of these trees to supply his own wants. (S. P. I. No. 21987.)

The stock upon which the Chinese graft their large-fruited varieties is the wild *Crataegus pinnatifida*, growing in many places in the mountains in northern China, Manchuria, northern Korea, and eastern Siberia. It is mostly seen as a shrub. In favorable locations, however, it grows into a small tree. In general, the wild tree or shrub is well furnished with long thorns, while the large-fruited cultivated trees are entirely without them.

Even in the wild state there is a good deal of variation in the appearance and behavior of the plants. Some specimens have very small leaves and are heavy fruiters; others, again, are very large leaved and bear few fruits, etc., but they all seem able to stand drought, cold, and adverse conditions to an unusual degree, and they therefore hold out great promise as to their future behavior in the United States. (S. P. I. Nos. 17170, 17751, 20108, 20109, 20350, 21921, and 22607.)

LOQUATS.

[CHINESE NAME, "Bibaw."]

The loquat (*Eriobotrya japonica*) is in all probability indigenous to the hills of the mild-wintered, moist regions of central-eastern China. The writer observed some specimens growing wild among the scrub in the region near Tangsi, Chekiang Province. That section is one of the most noted loquat regions of China. As far as the eye can see one observes nothing but loquat orchards, growing luxuriantly on the low, rich land, where the roots never suffer from lack of water.

There are several varieties of loquats in cultivation, differing a good deal in flavor, color, and quality. The finest kind is considered to be the white loquat, the fruit of which is said to be of a pale-yellowish color and of a very fine flavor. It is called in Chinese "Pai bibaw," or white loquat. (S. P. I. No. 22976.)

The different varieties are all grafted on seedling stock; but as the Chinese are not always very successful with their grafting, they generally lose a large percentage of them, and thrifty young plants are exceedingly hard to obtain.

The Chinese consider the loquat a very profitable tree, although apparently it bears a good crop only every two or three years. Rev. Alexander Kennedy, a missionary in Tangsi, who assisted us a great deal in obtaining various plants, stated that in the spring of 1906 the loquat crop was so great in his vicinity that from the village of Tangsi, alone, twenty thousand dollars' worth of fruit was exported.

JUJUBES.

[CHINESE NAME, "Tsao."]

CULTIVATED VARIETIES.

The jujube (*Zizyphus sativa*) is quite an important fruit in northern China, grown everywhere in those sections where winter temperatures are not too low. The trees can stand a remarkable amount of neglect without any apparent detriment. They are found equally productive on a piece of strongly alkaline land or in an inner courtyard where the ground has been tramped down until it is as hard as stone. (See Pl. V, fig. 2.)

The soil best suited to this fruit seems to be a porous clay, charged with more or less alkaline matter, like the loess in northern China. The jujube also thrives better in regions where the rainfall is rather light and the winters dry and cold than in moist, mild-wintered sections.

In general, jujubes are grown in small groves or as single trees, but here and there one also meets regular orchards of them, covering perhaps 10 or 20 acres. In some localities the farmers plant them in rows through the fields. It seems that planted in this way, at a distance of from 5 to 10 feet apart, they produce the largest quantity and the best quality of fruit. When in regular orchards the distance apart is from 15 to 25 feet, depending upon the variety and upon the personal preference of the planter.

The farmers, here and there, also have the habit of ringing their trees every year, claiming that thereby they considerably increase the crop. (See Pl. VI, fig. 2.) The jujube is about the only fruit tree around the roots of which the soil is not regularly cultivated, because the yield is found to be just as large without this work as with it.

There are a great many varieties of the jujube in cultivation, probably not less than a hundred, varying in size, color, shape, quality, etc. As the varieties do not come true to seed, the trees are mostly propagated by the suckers which are nearly always found at their bases. Root cuttings can also be taken. Some varieties, however, do not readily produce suckers, and root cuttings are not successful. Then the Chinese resort to grafting the scions on wild stock. This grafting practice, however, seems to be confined to only a few localities, where the growers are men of considerable experience.

The fruit of these jujubes is nearly all of a shining brown color and is very plump when fresh. When dried it has more of a red color and becomes shriveled. It is eaten fresh, dried, preserved in sugar, stewed, or smoked. Some varieties are better for one purpose, others for another.

The different varieties that came under the writer's notice are enumerated as follows:

"Ming tsao," a rather large-fruited variety, growing near Peking and Jehol, China. The fruit is of a light brown-red color, from 1¼ to 1½ inches long, of oblong shape, and quite sweet. The trees remain small, grow very erect, occupy but little space, and are almost devoid of spines. They sucker and spread very rapidly when young.

"Ya tsao," growing near Jehol, China. The fruit is large, from 1½ to 2 inches long, tapering toward the peduncle, of a dark brown-red color, and not very sweet. The trees remain small, grow fairly erect, but are very spiny, and sucker and spread freely.

FIG. 1.—AN OLD SPECIMEN OF THE "LANG TSAO," OR MELLOW JUJUBE, AT TSINTZE, SHANSI PROVINCE, CHINA, SHOWING THE PECULIAR HABIT OF GROWTH CHARACTERISTIC OF THIS VARIETY.

Introduction No. 22686.

FIG. 2.—A NEAR VIEW OF THE TRUNK OF A CHINESE SEEDLESS JUJUBE TREE NEAR LAOLING, SHANTUNG PROVINCE, CHINA, SHOWING THE RINGS THAT HAVE BEEN MADE EACH YEAR BY SAWING THROUGH THE BARK TO MAKE THE TREES BEAR MORE HEAVILY.

"Mu shing hong tsao," growing at Tsintze, Shansi. The fruit is of a red-brown color, of medium size, oblong, tapering toward the apex, and can be kept a long time. The trees grow to a large size and become very old. (See Pl. IV, fig. 2.) When old they are very little branched, have no spines, and sucker but little. (S. P. I. No. 22684.)

"Hu ping tsao," meaning bottle jujube, growing in Tsintze, Shansi. The fruit is large, oblong, and of a shining red color. It is usually eaten after having been soaked a couple of months in weak Chinese spirits. This variety is considered locally as the best grown. The trees do not reach a large size, are planted close together, from 6 to 8 feet apart, are spineless, and sucker but little. (S. P. I. No. 22683.)

"Tsui ling tsao," meaning fragile jujube, growing in Tsintze, Shansi. The fruit is oblong, of red color, is said to break easily on falling, whence its name, and is a poor keeper. The trees grow to medium size, are spineless, and sucker but little. (S. P. I. No. 22685.)

FIG. 11.—Chinese smoked jujubes. The jujubes of this variety are called "Yuen ling tsao" or "Su hsin tsao" when fresh, but go under the name of "Ghae tsao" when smoked. They are largely shipped to southern China, where they find a ready market.

"Lang tsao," or mellow jujube, growing in Tsintze, Shansi. The fruit is small, oblong, red colored, and of a mellow, sweet flavor. It can not be kept long. The trees grow large and spread out very much, behaving quite differently in this respect from other varieties. (See Pl. VI, fig. 1.) (S. P. I. No. 22686.)

"Yuen ling tsao" or "Su hsin tsao," a round-fruited variety of dark brown-red color, found near Hweigörr, Shantung. Its fruit is smoked and exported in large quantities to southern China, where there is a great demand for smoked jujubes (fig. 11).

"Wuhu tsao," or seedless jujube, growing near Laoling, Shantung. This variety is said to be the only seedless variety in the whole Chinese Empire and is sent every year as a present to the Emperor at Peking. It has made the Wuhu magistracy, where it grows, famous all over China for its jujubes. The fruit is not absolutely seedless, but the kernel is so soft that it is practically imper-

ceptible when eaten and the fruit may therefore safely be called seedless. The fruits are rather small, of a dark brown-red color, and very sweet. They are excellent when boiled with rice or millet, make delicious stewed compote, and can be eaten dried with peanuts, the same as raisins and almonds. Foreign soldiers in Peking, with whom the writer tested a few pounds, were remarkably fond of them.

The trees grow only to a medium size. They are usually planted in rows through the fields at distances of from 8 to 10 feet apart. The Chinese ring the trees every year at the time of the setting of the fruit by sawing through the bark close to the base of the trunk. They say that if this is not done half of the fruit is thrown off by the tree, so that by this method they double the crop. (See Pl. VI, fig. 2.) The fruit of the ringed trees, however, is not so sweet by far as that coming from the unringed trees.

FIG. 12.—Chinese jujubes of the "Chin sze tsao" variety, used extensively in the manufacture of the so-called honey jujubes ("Mi tsao"). A remarkably sweet variety.

"Chin sze tsao," a rather small but very sweet variety, growing at Laoling, Shantung (fig. 12). This variety is said to be one of the best for the manufacture of the celebrated honey jujubes. The fruit is of a light brown-red color; the trees are of medium size, with much of the habit of the seedless jujube.

"Tun ku yu tsao," a flat jujube, growing near Chinanfu, Shantung. This variety has a dark-brown color and is remarkably sweet; considered locally one of the best varieties for eating fresh.

"Twen ku lu tsao," another flat variety, growing near Chingchowfu, Shantung. The fruit is of medium-large size, of dark-brown color, and is also very sweet. It does not keep long. The trees are of medium growth, bear but little fruit, and sucker very little. They are propagated by being grafted upon the wild stock.

Besides the varieties mentioned there are scores of others that did not come under the writer's personal observation, but which are mentioned in various Chinese publications. One variety is even said to be white.

There is an article often served to foreigners in China in homes and in hotels looking strikingly like the Persian date. This is the celebrated "Mi tsao," or honey jujube (figs. 13 and 14). To prepare this the Chinese take large, sound, dried fruits and boil them thoroughly in sugared water, after which they are taken out and dried in the sun or wind for a couple of days. When sufficiently dry they are given a slight boiling again and are partly dried. When dry enough to be handled, the skin is slightly slashed lengthwise with a few small knives tied together. Then the fruits are given a third boiling, now, however, in a stronger sugar water, and for the best grades of honey jujube honey is added. When this process is finished they are spread out to dry, and when no longer sticky are ready to be sold. The best grade of these honey jujubes sells for 40 cents Mexican a pound, and is obtainable in only a few of the larger cities of China. In case the American people should take to growing the jujube, they would find a ready market for the better varieties for use in the manufacture of various confections.

FIG. 13.—Small honey jujubes, not as high priced as those shown in figure 14, though of as good, if not better, flavor.

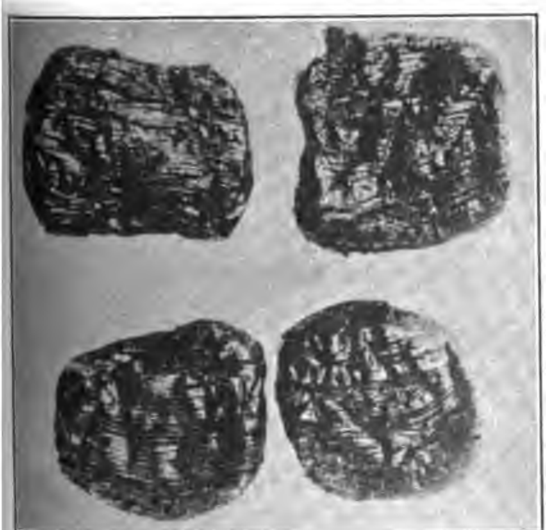

FIG. 14.—The best of the Chinese honey jujubes. These are excellent candied fruits which deserve to become well known in America.

The trees withstand considerable alkali and drought.

DRAGON'S-CLAW JUJUBE.

With so many varieties of jujubes in cultivation it is not surprising that one kind has been produced that has an ornamental value. This is the quaint "dragon's-claw" jujube (*Zizyphus sativa tortuosa*) or, in Chinese, the "Lung tsao tsao shu." This variety has peculiar gnarled and twisted branches and is very rare. The rich Chinese prize them highly as horticultural curiosities. The trees are propagated by being grafted on the wild jubube. (S. P. I. No. 22914.)

THE WILD JUJUBE.

Finally we come to the original wild jujube (*Zizyphus sativa spinosa*) from which the cultivated varieties have been derived. This species grows wild on most of the walls of the northern China cities, and is also to be found in the most out of the way, stony, and sterile locations. It has ugly hooked spines, which easily tear one's clothes and break off in one's flesh. The fruit is small and round, of a brown-red color, and has a pleasant sour taste. It is collected by old women and children, and an inferior paste and preserve are made from it. The very spiny branches are used as fencing material and keep intruders away by their forbidding appearance. In general, this wild jujube grows only as a bush; but when left alone in favorable locations it reaches the size of a tree from 20 to 30 feet high, with a trunk more than a foot in diameter. It becomes less spiny when large; but it is still far from easy to climb one of these trees without the loss of some blood. (S. P. I. Nos. 17892 and 21995.)

GRAPES.

[Chinese name, "Poo tao."]

CULTIVATED VARIETIES.

The grape is as much esteemed by the Chinese as by western nations. *Vitis vinifera* is not a native of China, but was introduced there from central Asia by the Emperor Wu ti, who in the first century before our era sent ten envoys to various countries west of China, who brought back grapes and alfalfa.[a]

How many varieties of grapes were originally introduced it would be hard to ascertain, but there must have been several, for at present a good many varieties are being grown in northern China.

There is a very fine white variety cultivated near Changli, having round berries and possessing a good flavor. It ripens in the latter part of September (S. P. I. No. 17155). Another white kind occurs near Hsuenhuafu. This variety is the highest priced of all the Chinese

[a] Sampson, Theo. Grapes in China. Notes and Queries on China and Japan, April, 1869, p. 50.

grapes and is to be had only in limited quantities. The bunches are rather large, the berries much elongated, and the flavor is sweet and refreshing. It is a good keeper, the fruit being kept in paper-lined baskets or in jars in cool places until February (S. P. I. Nos. 16927 and 17156). There are also some seedless white grapes in northern China, one variety being apparently the same as the Sultanina, or so-called Thompson Seedless. (S. P. I. No. 17160.)

There are also several varieties of purple grapes, central Shansi, especially, being renowned for them. One variety can be kept for almost a whole year if the fruit is carefully put in baskets and jars and kept in cellars which are cooled by ice.

The culture of grapes in China is somewhat different from what it is in other lands. The plants are always grown trained over arbors, with very long main leaders. In the month of October, just after a cold snap, the vines are taken from their supports, skillfully pruned, and then tied together in long bundles. If the main leaders are very long they are bent around to make the bundle shorter. Pits from 4 to 6 feet deep are dug, wide enough for a man to work comfortably in and as long as the tied-up bundle of the grapevine requires. The vines are now laid down in these pits, which are covered with sorghum stems and old matting, over which a couple of feet of soil is put (fig. 15). Care is always taken to leave a few air holes, which are left open in warm weather but are closed up entirely in case a blizzard occurs. The root from which the stems originate is never taken up, but some old matting is put around it and the whole is covered with soil to the depth of a few feet.

FIG. 15.—A grapevine of a tender variety just removed from a trench where it was protected for five months. Photographed March 31, at Tientsin, China.

In visiting a vineyard in China in the winter, unless one's attention were drawn to it, few people would suppose that the apparently barren spot they were walking upon was covered in summer with a luxuriant growth of choice grapes. This practice of burying the grapevines that would not be able to pass unprotected through severe winters is certainly worthy of general attention. It can not

be done in the United States on a large scale, as the high price of American labor would be prohibitive, but in the Rocky Mountain section of the United States, especially, the people could have choice varieties of grapes for their own table use if they would take the trouble to protect the vines in winter in this way.[a]

RAISINS.

Raisins are not common in China, and those seen there are a small, seedless, greenish-white kind, said to be made from grapes grown in the neighborhood of Kweihuacheng, Mongolia, a district with very dry air.

VARIOUS SPECIES OF WILD GRAPES.

[Chinese name, Shan poo tao.]

In northern China, Manchuria, and eastern Siberia a wild grape (*Vitis amurensis*) grows. This grape is found in dense thickets overrunning shrubs and trees. It is a rather prolific bearer, the bunches and berries being small, however, and rather sour; but the plant is so remarkably hardy, standing temperatures of −40° F., that there may be a possibility of using it in hybridization experiments. In its wild state it is collected by the Chinese and Russians and eagerly eaten. In eastern Siberia the writer also tasted some inferior wine and some good vinegar that had been made from it by a Russian settler. (S. P. I. Nos. 19477, 19600, 20347 to 20349, and 22601.)

Besides the *Vitus amurensis*, one finds here and there various other wild species. In the Boshan district is found a wild grape called "Ya pu tao" (S. P. I. No. 21979). From it the Chinese make a fairly good wine, which is remarkably strong. In the Lungtung district of Shantung there are two other species, both bearing edible berries. In the Mokansan region, to the southwest of Shanghai, one finds grapes that have many spines along their branches and bear edible berries. They are even sparingly cultivated by foreigners. In all probability they are a species of Spinovitis (perhaps *S. davidi*) and might be fitted for hybridizing with better varieties to produce strains of grapes that could stand a greater degree of moist heat than our present good varieties are able to do.

THE CITRUS GROUP.

Numerous, indeed, are the various species and varieties of Citrus in China. As is well known, southern China is supposed to be the home of the sweet orange (*Citrus aurantium sinensis*). Besides this species,

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[a] This method is practiced to a limited extent with tender varieties in the Northern States and in Canada.—William A. Taylor.

mandarins and tangerines (*C. nobilis*) and kumquats (*C. japonica*) are in all probability natives of China, the last two probably coming from the mild, equable climate of south-central China. In the vicinity of Hangchow wild pomelos occur, while in Shensi and Shantung *Citrus trifoliata* is found in a wild state.

There are said to be more than 80 different kinds of edible oranges growing along the southeastern coast of China and on the numerous islands fringing that coast. A few that came under the writer's notice are as follows:

SWEET ORANGES.

There are several varieties of the sweet orange (*Citrus aurantium sinensis*) in China. They appear on the markets in winter and are chiefly from southern China. One variety, said to grow near Canton, is of medium size and very sweet. It is especially in favor with the foreign residents. Blood-red oranges of this type are also occasionally seen.

MANDARINS.

Under mandarins (*Citrus nobilis*) we may group the large flat fruits with a loose, generally dark orange-red skin. The trees need rather high temperatures to thrive. The leaves and wood are of a much stronger growth and are very much darker colored than those of the tangerines. The trees are not so prolific. The Chinese possess some excellent varieties of mandarins. One very large one is perfectly seedless and very sweet. It grows especially well on the islands off the coast between Foochow and Amoy. Some excellent varieties are also found in the Szechwan Province and above Ichang on the Yangtze River. To the same group belong the so-called bitter or tonic oranges from Wenchow, Chekiang Province. This fruit possesses a bitter flavor that makes it very acceptable on the breakfast table, it having tonic properties similar to those of the pomelo.

TANGERINES.

Under tangerines (*Citrus nobilis*) are placed the small loose-skinned varieties, mostly of a light orange color and generally quite well supplied with seeds. The leaves are small and of a light green color. The branches, although thin and long, are closely massed, thus making the trees very dense and round headed. The trees seem to be able to stand a considerable degree of cold. There are several varieties, differing much in size and flavor. One rather small variety is grown extensively near Hangchow in the Chekiang Province. When these groves were visited in the spring of 1906 many trees were completely bent down and a good many limbs had been broken off by a

10-inch snowfall two days before, but although the trees had been shattered by the snow they had not suffered at all from the cold.

KUMQUATS.

The kumquat (*Citrus japonica*) is a small fruit which is very much appreciated in China. All who have ever had a good Chinese dinner know how this fruit is served, preserved in sugar or sirup. It is worthy of being more widely known by the western nations than it is at present. There are a few varieties of this fruit cultivated by the Chinese differing in size and shape. The elongated form, however, seems to be the most highly appreciated and is found in the fall of the year in all the markets and fruit stands, being sent even as far north as Peking.

POMELOS AND SHADDOCKS.

Several varieties of pomelos and shaddocks (*Citrus decumana*) are found in China. The orchards, however, exist near Amoy and Canton and the writer never saw any trees except some dwarfed ones in nurseries. The fruits themselves are plentiful in Shanghai, being served even on the tables of the foreign hotels. One variety of pomelo is particularly good and is called by foreigners the "Amoy" pomelo. It is of a flat shape, has a loose skin, and its segments separate as easily as those of an orange. It has a sweet flavor and when it is fresh the fruit is quite juicy, differing from some other kinds that are extremely dry, even when not old. This class of sweet pomelos, the segments of which separate easily, is never served as a breakfast fruit but is eaten as a dessert, served in segments. Coming after the oranges have gone, this variety fills a decided gap in dessert fruits on the tables of people living in the Far East. (S. P. I. Nos. 21870 and 25506.)

LEMONS.

In China the lemon is apparently not grown as a fruit tree, for lemons are rather scarce and expensive, being imported from outside countries. In Peking and Tientsin the price of lemons in winter is sometimes as high as 20 cents in our money apiece.

As an ornamental plant, however, lemons are very much appreciated as dwarfed pot plants. The idea is to have as many fruits as possible on the smallest possible plant. A plant with a dozen or more fruits on it will sell in Peking in the winter for as much as $10. The particular variety used for this purpose slips easily and is raised from cuttings. The fruit is large, very smooth, and thin skinned, very juicy, only slightly sour, and is practically seedless. (S. P. I. Nos. 21905 and 23028.)

FINGERED LEMONS.

The fingered lemon, or "Buddha's hand" (*Citrus medica digitata*), is a queer fruit largely grown by the well-to-do Chinese as an ornamental pot plant. The strange fruits are greatly prized by the people as presents and as religious objects. They are supposed to bring good luck to the household. Indeed, so highly are they valued that in the north a good sound fruit sells for one Mexican dollar.

NOVEL CITRUS FRUITS.

In Peking one can sometimes buy in the winter some strange orange-like fruits. They have the appearance of a warty Satsuma orange, but the flesh is fibrous, sour, bitter, and not edible. They are used as room perfumes, like quinces. (S. P. I. No. 21904.)

In the neighborhood of Hangchow there is a peculiar citrus fruit growing wild upon the hillsides. The fruit is very large, 4 inches long by 2½ to 3 inches in width. The skin is of a dark yellow color, thick but loose, and contains a peculiarly pungent volatile oil. The pulp is of a refreshing sour flavor, between that of a lemon and a pomelo; in fact, it serves as a lemon for foreigners in that part of China. It is full of large flat seeds, resembling those of the pomelo. The trees grow straight and tall, are rather bare branched, and are furnished with large spines. They are capable of standing severe frosts and heavy snowfalls without being hurt, and might therefore be utilized as stock in the United States. The Chinese names for this fruit are "Schu yu" and "Ning bon." (S. P. I. No. 18439.)

Besides the citrus fruits mentioned, the Chinese cultivate several others, some of which the writer was not able to see in fruit. In some small nurseries one often finds twenty or more citrus varieties, all grown in pots and vessels as dwarfed specimens. Some are slipped, others have been layered, some are grafted upon *Citrus trifoliata*, others, again, on seedling stock of some kind or other. They are all in great favor as pot plants and there is much demand for them.

NAGIS.

[Chinese name, "Yang mae."]

The nagi (*Myrica nagi*) thrives to perfection on the slopes of the hills in the Chekiang Province. It also occurs on the Chusan Islands and in other places in southeastern China. It prefers a well-drained situation, and where found wild it often grows in rather poor, rocky soils, in semishady localities. The wild shrubs or small trees grow very straggling and open. In cultivation, however, where they get full sunlight and proper care, they grow dense and

bushy and are very ornamental, especially in early summer, when the masses of carmine fruit contrast beautifully with the glossy light-green foliage.

Several varieties are cultivated in China, varying in color from dull white, yellowish red, rosy red, and carmine to black red; in size, from a cherry up to a medium-sized plum; and in flavor, from very acid to refreshingly sweet. The best varieties are grafted upon wild or seedling stock, but it is no very easy undertaking to do this. The trees can be transplanted only with the greatest difficulty, and for that reason plantations extend but very slowly. Wherever the Chinese nagi could be grown in the United States its fruit would be a very pleasant addition indeed; for besides being very agreeable when eaten fresh, it can be stewed, preserved, and used in a multitude of ways. Very good pies are made from it, and as an ingredient in fruit sirup it is very refreshing. (S. P. I. Nos. 22904 to 22906, and 22977.)

POMEGRANATES.

[CHINESE NAME, "Shuh lu."]

Pomegranates (*Punica granatum*) are not indigenous to China but were introduced there from central Asia in the beginning of our present era. To-day they are still considered somewhat as exotics, for the plants are mostly grown as ornamentals. The fruit is considered to be of more or less medicinal value.

In the Shantung Province, however, one finds large specimens of pomegranates growing in the gardens, and quite a number of different varieties can be seen. There are dwarf varieties that grow only a few feet tall and bear but a few small scarlet fruits, while others grow from 15 to 20 feet tall and bear fruits one or more pounds in weight. There are varieties that have a white rind and are red inside and other kinds that are white both outside and inside. A great part of all the pomegranates in China are double flowered and are grown only for ornament. There are pygmy varieties with double dark-red flowers, others with light-red ones; while among the tall kinds one finds every degree of variation, ranging through pure white, striped, and pale-red flowers to very dark red ones.

LITCHIS.

[CHINESE NAME, "Lei tchee."]

The litchi (*Litchi chinensis*) is one of the most popular fruits in China; in fact, in the south it seems to occupy about the same place that the strawberry does with us, as far as appreciation is concerned. No good dinner, even in northern China, is really complete without some of these delicious little fruits. They are eaten fresh, dried, or

canned. The litchi has the same reputation that the pineapple has, that is, it is thought by some to be improved by being canned.

There are a great many varieties of litchis as to size, color, flavor, and size of kernel. They are strictly semitropical plants and in China they occur along the coast only as far north as Foochow, on the twenty-sixth parallel of latitude. They require a rich, loamy soil and should not be allowed to suffer from lack of moisture. The trees are propagated by inarching upon seedling stock, but the Chinese admit that the plants are hard to propagate. The dried fruits of the litchi are the so-called Chinese nuts which have become quite common in our American markets.

LONGANS.

[CHINESE NAME, "Long an."]

The longan (*Euphoria longan*) is a near relative of the litchi. The fruit is much smaller and not nearly so well flavored when raw. When canned, however, the longan is improved considerably and is perhaps even of a more delicate flavor than the ordinary litchi. It is also a strictly semitropical tree, but can stand more hardships than the litchi. The fruit, which is naturally brown, is generally artificially changed to a chrome yellow. It is eaten fresh, canned, or dried. In the last condition one can obtain it at the Chinese New Year time even in the most northern cities of the Empire. There are several varieties of longans, differing in size of fruit, productivity, and size of kernel. Their northern limit of growing seems to be, like that of the litchi, the region around Foochow.

FIGS.

The fig (*Ficus carica*) is grown in northern China only as an exotic, mostly in pots and tubs. In the milder parts of China, however, one finds here and there big specimens out in the open. The writer noticed black and white varieties, but the fruits are not great favorites with the Chinese, apparently, and figs are but sparingly grown.

GUAVAS.

Guavas (*Psidium cattleyanum*) are never seen in northern China and are but sparingly met with in central China, and then only as pot plants. Farther south, however, they seem to be grown in regular plantations, as has been reported by various writers.

BANANAS, PINEAPPLES, ETC.

Bananas, pineapples, carambolas, and various other strictly tropical fruits are grown in the extreme south of China; but although the writer observed the fruits in northern markets he was never able to see the plants growing in their various districts.

THE CANARIUM.

The canarium (*Canarium* sp.) closely resembles our green olive. It is hawked all over the Empire and is mostly eaten fresh, or while still unripe is pickled in brine. It is considered an excellent promoter of digestion and an appetizer. Besides the fresh fruit, one can obtain it dry salted, dry sugared, or preserved in sirup. In the last two ways it has a very pleasing flavor, comparing favorably with our preserved citron rind, and could safely be introduced into our western lands as a table delicacy. The shrubs, or small trees, can not stand much cold. Their northern limit on the coast of China seems to be Foochow.

MULBERRIES.

[CHINESE NAME, "Pai sang shu."]

In the neighborhood of Peking a variety of mulberry (*Morus alba*) is grown which produces large white fruit that is very sweet to the taste. It ripens in early June, and is but sparingly met with for sale.

ACTINIDIA.

ACTINIDIA KOLOMIKTA.

There are several species of Actinidia in the Orient. The most common in northern China, Manchuria, northern Korea, and eastern Siberia is *Actinidia kolomikta*. This vine grows here and there in dense masses in the open forests, sometimes covering large areas, crawling over bowlders and smothering all small shrubs. There is much variation in its habits. Some plants are of an open growth, while others are extraordinarily densely branched.

The fruit, too, varies in size and shape, some kinds being as small as and even rounder than a gooseberry, while others are elongated and of the size of small plums. The color is either bright or dull green.

In the foliage one observes at times some curious variations of color. Some plants produce leaves that are either entirely or in part white, silvery colored, or spotted; other plants show a similar variegation, but in the red or rosy-red tints. These variegations are strikingly beautiful when seen in the wild state. The white one produces the effect of a shrub covered with thousands of large white flowers.

The fruit of *Actinidia kolomikta* is edible and is eagerly collected by the inhabitants of the countries where it occurs. The Russian settlers in eastern Siberia dry it and keep it for winter use. They call it "kishmis" and use it baked in bread and pastry. (S. P. I. No. 19479.)

ACTINIDIA ARGUTA.

The species *Actinidia arguta* also occurs wild in Manchuria and northern Korea. It is of much stronger growth, but is seen far less often than the first species. The fruit is larger than that of *Actinidia kolomikta* and is also collected and eaten by the natives. According to information obtained from Unsan, northern Korea, the fruit is called "tara" in that region and is well liked.

ACTINIDIA CHINENSIS.

[CHINESE NAME, "Yang tao."]

The species *Actinidia chinensis* seems to be the largest and most important of all. It grows in the mild-wintered Yangtze Valley, and as far as the writer was able to ascertain is not cultivated at all. The vine is a very rank grower, attaining large dimensions. The fruit is of the shape of a small hen's egg, has a rough skin, and is of a rusty color. It tastes something like a gooseberry, but has other flavors added to it. The missionaries prepare a jam from it that is of very good quality. Plants of this species have been widely distributed of late, and will no doubt show in the near future whether they are productive enough to warrant the very large space they require for successful development. (S. P. I. Nos. 11629 and 21781.)

MISCELLANEOUS SMALL WILD BERRIES.

As has been stated, the Chinese do not seem to like soft fruits very well, especially the wild, berrylike kinds. This is probably the reason why they have never developed any of the excellent wild forms of Rubus which they possess. The ordinary red raspberry (*Rubus idaeus*) grows in large quantities in the mountains of northern China, Manchuria, and eastern Siberia, and although the fruit is not very large it is of a good flavor.

Various other species of raspberries, thimble berries, blackberries, and all sorts of intermediate forms bearing white, yellow, red, or black fruit occur all over China. Dr. Augustine Henry and Mr. E. H. Wilson have collected scores of good species in central and western China, some of which in the near future will give rise to entirely new strains.

The genus Ribes has some promising species in the Orient. Here and there in the high mountains of northern China one finds wild gooseberries and various kinds of wild currants that seem to be able to withstand a drier climate than the varieties of western Europe and may therefore be used in hybridization work.

When traveling through northern Korea in the summer and fall of 1906 the writer found in the highlands of the Changpektchang region hundreds of acres covered with fine blueberries (*Vaccinium myrtillus*), on which his party feasted until their tongues and palates were dark purple and their teeth were on edge. These blueberries are certainly worthy of cultivation in cold, bleak districts where other berries will not grow. Even in the wild state there is a considerable degree of variation among them as to size and sweetness of fruit, and superior varieties could easily be selected and multiplied.

Here and there in shady, moist places, in the same localities where the blueberries were growing, masses of mountain cranberries (*Vaccinium vitis-idaea*) were noticed, but the scarlet, fine-looking berries were somewhat too bitter to be palatable.

In the cooler parts of northern China, Manchuria, northern Korea, and eastern Siberia the snowball (*Viburnum opulus*) often occurs in large masses. In some places the natives collect the scarlet, juicy berries and make preserves of them by boiling the fruit and mixing sugar with the paste.

Schizandra chinensis is a small climbing vine, growing in shady thickets in Manchuria, northern Korea, and eastern Siberia. It bears long, dense clusters of scarlet berries which are eaten by the natives, who claim that the fruit possesses medicinal properties, being a blood purifier. The dried fruit is exported as medicine in large quantities from Manchuria to various Chinese cities. To us, however, this plant would be of value mainly as a graceful ornamental climber. (S. P. I. Nos. 19602 and 20361.)

Besides these regular fruits, many wild things of minor importance are used for food. One of these is too curious to omit. There grows in some parts of China a species of hackberry (*Celtis sinensis*). This tree is sometimes so badly attacked by a gall that it becomes stunted. The Chinese, however, eat these galls while green and before the insect inside is entirely grown. They say that the flavor is exactly like that of a cucumber, and for this reason the tree is called the "Shan huang kwa shu," or wild cucumber tree.

COLD-STORAGE METHODS IN CHINA.

It is a fact of peculiar interest that certain methods or practices which our present generation considers to be particularly its own are found to have been practiced for no one knows how long in some of the oldest countries of the globe. Cold storage is one of them. The Chinese understand the principles of cold storage thoroughly. They are able to keep grapes from one year to another by storing them in deep, dugout cellars that are kept cold with baskets of broken ice placed among the baskets of fruit.

The fruit merchants usually keep perishable fruits in their stores by means of large earthen jars with very thick walls. Broken ice is put in the bottom of the jar and upon this are placed woven wicker baskets in which the fruit is kept. The jar is closed with a wooden cover that often has a strip of felt around it. It is remarkable how well such a simple contrivance serves its purpose.

To obtain the necessary ice there is great activity in the neighborhood of cities and villages in the winter time. Ice even as thin as half an inch is gathered. It is stored in houses with very thick mud walls and kept there nearly the whole year.

NUTS AND NUT CULTURE.

Nuts are appreciated by the Chinese to the same extent that they are all over the world, but nut culture is as little practiced in China as it is elsewhere, for nut-bearing trees and shrubs seem to have the reputation of not needing much cultivation. One therefore finds that a great many of the various nuts obtained in China have been collected from trees and shrubs in a wild or semiwild state.

The nuts which came under the writer's observation are as follows:

WALNUTS.

[Chinese name, "Ho to."]

The walnut (*Juglans regia sinensis*) is a native of northern China and thrives to perfection in the rich, loamy soil of some of the broad, sheltered valleys of that country. In some sections the trees are grown in regular orchards, in other localities one finds them planted here and there as solitary specimens. The latter practice is especially common in the narrow mountain valleys, where terraces have often been made to supply the trees with a sufficient quantity of soil.

The Chinese have not learned the art of grafting or budding the walnut, and all the trees, therefore, are seedlings. Hence, there is an enormous variation in the habits of the trees and in the size and quality of the nuts. In some sections very superior strains of nuts exist, while elsewhere the quality is poor. In the vicinity of Changli, Chihli Province, there are some walnut orchards in which the trees vary to a remarkable degree. Some produce small hard-shelled nuts of poor flavor, while others bear fine large nuts, with a really fine flavor, and having shells so thin that they can be cracked with the fingers like a peanut. Between these extremes one finds many gradations in hardness of shell, size, and flavor. It is very likely that some kinds of these Chinese nuts may prove to be much hardier than our present Persian strain of walnuts and in all probability they will thrive especially well in certain sections of the southern Rocky Mountain region. (S. P. I. Nos. 17745, 17746, 17943 to 17946, 18256, 18257, 18263, 18603, and 18604.)

WILD WALNUTS.

[CHINESE NAME, "Shan ho to."]

At the present time the walnut is but very sparingly met with in the wild state. Northern China has been settled too long to afford us the opportunity of seeing much of her original wild arboreal vegetation. In the Pangshan district, however, to the east of Peking, one may still find a few specimens of the real wild walnut. They are found in the mountains, growing in ravines among large bowlders. The trees are smaller and less vigorous in growth than the cultivated ones. The leaves and nuts are also smaller and the latter less sweet than those from cultivated trees, but otherwise there is little difference. (S. P. I. No. 21877.)

CHESTNUTS.

[CHINESE NAME, "Li tze."]

The ordinary Chinese chestnut (*Castanea* sp.) grows wild on the slopes of rocky mountains in northern China and southern Manchuria. It is mostly found in groves, growing among rocks and bowlders, and even in its wild state it varies considerably in the size and flavor of its nuts and the spininess of the burrs. The Chinese name for the wild form is "San li tze." (S. P. I. No. 21875.)

The nuts have been planted to some extent on the mountain slopes by the Chinese, where the trees receive more or less cultivation. All the trees being seedlings, there is very great variation among them in regard to their productivity and the size and relative sweetness of the nuts. The nuts are sold extensively in autumn and early winter in all Chinese towns, after being roasted in sand with which molasses has been mixed. This roasting in sugared sand bleaches the nuts somewhat, makes them shiny, and cracks them open but very little.

The chestnut of northern China is quite distinct from that of Japan; it can stand great heat and drought, and may be especially useful in the Rocky Mountain region of the United States. (S. P. I. Nos. 17876, 17877, and 17896.)

There is a very slender-leaved chestnut found growing in some of the ravines of southeastern Manchuria and northeastern Korea. The nuts are small, but when the tree is in flower it is very ornamental, its snowy-white masses of catkins contrasting vividly with the slender, glossy, green leaves.

In the more elevated mountain regions of China a dwarf chestnut occurs, generally as a shrub several feet high. The nuts are small but very sweet. The whole plant is very similar to the North American chinquapin. It can be used as a fruiting shrub. Its nuts are very sparingly seen in the markets of central China during the early winter.

HAZELNUTS.

Three wild species of hazelnuts occur in the mountains of northern China, Manchuria, and eastern Siberia. They are *Corylus heterophylla*, *C. mandshurica*, and a third species. They are never cultivated, but the nuts are collected and sold on the markets throughout the Far East. They are inferior to the filbert, but seem to be able to stand, in general, more drought and hardship. For this reason they might be tried in the drier sections of the United States where ordinary filberts do not succeed.

EDIBLE PINE SEEDS.

Pine kernels are sold in fruit stalls and markets all over the Far East and are eaten as delicacies. Most of these come from the *Pinus koraiensis*, which grows as a stately tree in the virgin forests of Manchuria, Korea, and eastern Siberia. They are called "Sung tze." (S. P. I. Nos. 20089, 20090, 20315, 20316, and 23220.)

Besides this pine, there are a few others that supply these kernels. In the Province of Shansi a small round pine kernel is sold. It may be the seed of *Pinus bungeana*. It is called "Kuo tze" and "Sung tze." (S. P. I. Nos. 21997 and 22691.) In southern and central China some very elongated kernels are occasionally to be had. These nuts are often used by the higher classes for cake and pastry.

APRICOT KERNELS.

Foreigners in China are often served in various homes and hotels with so-called almond cake. One of the main ingredients of this cake is sweet kernels, so closely resembling almonds that even intelligent foreigners believe that they are eating genuine almonds. This supposition has given rise to the statement that almonds grow in China. These so-called Chinese almonds are the kernels of a particular kind of apricot (*Prunus armeniaca*), grown exclusively for its seeds.

There are several varieties of apricots that produce these seeds. The best one has small red fruit with large, medium-soft stones and sweet kernels. The tree of this particular variety is of very erect growth, quite distinct from all other varieties of apricots. It is propagated by grafting upon seedling stock.

Another variety bears somewhat larger fruit, also of a red color, but the tree is of an open habit. Then there is a yellow-fleshed variety that resembles the preceding one very much in habit of growth. The stones of the last two varieties are not so easily cracked, however, as those of the first-mentioned kind.

Another variety that came under the writer's notice has a bitter kernel, used only in small quantities to give flavor to confectionery

and to make the so-called Chinese almond soup. In preparing the latter, rice is cooked until it is quite soft, then pounded and mixed with water until it closely resembles milk, then a few bitter "almonds" are ground up and mixed with this rice milk, some sugar is added, and it is served hot. It makes a delicious, stimulating soup of which the Chinese are very fond of partaking in the evening just before retiring.

The sweet apricot kernels are often served with true nuts and raisins. Sometimes they are salted. They look and taste exactly like small salted almonds, so that it really is no wonder that foreigners have come to consider them as a particular kind of Chinese almond. (S. P. I. Nos. 17153, 17845, 18260, and 18261.)

GINGKO NUTS.

[CHINESE NAME, "Pai kua," meaning white nut.]

The gingko (*Gingko biloba*) is grown in China as a much appreciated tree in the courtyards of Buddhist temples and near shrines. The white nuts are eagerly collected, cleaned of the ill-smelling pulp that surrounds them, and sold as a delicacy, especially in central and southern China. They are always slightly roasted before being eaten, but their flavor does not appeal to the palate of the Caucasian race.

CASTANOPSIS SEEDS.

The castanopsis (*Castanopsis tibetana*) is a stately evergreen tree, bearing edible, chestnut-like seeds. The tree grows 100 feet tall and has a trunk several feet in diameter. It bears glossy dentate leaves, dark green above and rusty brown beneath, which sometimes reach a length of 1½ feet and a breadth of 9 inches. The tree is found sparingly in protected mountain valleys in the Chekiang Province. It was discovered in the vicinity of Hangchow by Bishop G. E. Moule, of the Church of England Missionary Society, through whose efforts we were able to obtain a small quantity of the seeds, which are not easy to obtain. The nuts being edible, the priests of the various temples are very fond of them, and the many rodents abounding there also get their share as soon as they ripen, so that one has to be on the spot at the right season to secure a supply.

This castanopsis will probably grow in those sections of the United States where oranges and loquats thrive, where the soil is rich and deep and where some shelter can be afforded to the plants, at least while they are young. (S. P. I. No. 22915.)

WATER CHESTNUTS.

[CHINESE NAME, "Feng ling."]

Peculiar water chestnuts (*Trapa bicornis*), resembling a buffalo ead, are extensively grown in all the canals and placid streams of he Chehkiang Province. The Chinese plant them in early spring nd protect the plants by means of fences of bamboo stalks staked in he water. The nuts are eaten boiled and taste somewhat like a erusalem artichoke.

The labor involved in collecting the seeds and protecting the lants makes this crop one that is not likely to succeed in any country xcept where labor is exceedingly cheap and plentiful.

VARIOUS EDIBLE SEEDS.

PEANUTS.

Peanuts (*Arachis hypogaea*) are cultivated extensively all over hina. They are grown for oil extraction and for food.

The nuts are planted in the spring in sandy soil and are harvested n the fall; but they are considered so valuable that the soil in which hey grow is sifted so as to get even the smallest nuts. A field of 10 r 20 acres that has been thus sifted, with the heaps of soil lying on t in regular lines, looks as if manure had been carted on in compact eaps.

There are but few varieties of peanuts in China. The ordinary arge kind is the same as seen elsewhere and is called by the Chinese he "foreign peanut." Its introduction seems to be quite recent. t is used almost exclusively as a delicacy, roasted as in western ountries.

There is a small variety, however, with a peculiar shrunken skin, hat is used in an entirely different way. These nuts are steamed vith salt water and kept in weak brine until used. They are everyvhere eaten cold as appetizers, and although small are really very alatable and nutritious. Sometimes the kernels are taken out, alted, and served at dinners, but on account of their small size they re being replaced by the larger variety. (S. P. I. No. 22022.)

WATERMELON SEEDS.

Watermelon seeds are in great favor with the Chinese as delicacies, nd no one can go to the theater or to a tea house without being ffered some. They are always served roasted.

There are several varieties—some red, others black, yellowish, and even white. The red varieties seem to be considered the best. The Chinese grow a few strains of these watermelons solely for their seeds, for which there is always a great demand. It might perhaps be profitable for American farmers to obtain a very large-seeded variety of watermelon and grow it exclusively for its seeds, to be exported to China.

SQUASH AND PUMPKIN SEEDS.

Pumpkin seeds of the species *Cucurbita maxima*, *C. pepo*, and *C. moschata* are roasted and eaten as delicacies all through China, and also by the Russian settlers in eastern Siberia.

BOTTLE-GOURD SEEDS.

Seeds of the bottle gourd (*Lagenaria vulgaris*) are boiled in salted water and eaten when cold as appetizing delicacies by the rural classes in China.

SUNFLOWER SEEDS.

Sunflower (*Helianthus annuus*) seeds are consumed extensively, either roasted or raw, as delicacies, all through China and Siberia. The black and white striped seeds seem to be the most in favor and are grown in great quantities for domestic use.

FIRMIANA SIMPLEX.

The seeds of the plant frequently known as *Sterculia platanifolia*, the correct name of which is *Firmiana simplex*, which is grown all through China as a favorite shade tree, are sold sparingly as delicacies in central China. They are far from being of good flavor, however, and as a food will never become of any importance to western races.

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O

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 205.

B. T. GALLOWAY, *Chief of Bureau.*

SEEDS AND PLANTS IMPORTED

DURING THE PERIOD FROM OCTOBER 1 TO DECEMBER 31, 1909:

INVENTORY No. 21; Nos. 26048 TO 26470.

ISSUED MARCH 17, 1911.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

BUREAU OF PLANT INDUSTRY.

Chief of Bureau, BEVERLY T. GALLOWAY.
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., October 31, 1910.

SIR: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 205 of the series of this Bureau the accompanying manuscript, entitled "Seeds and Plants Imported During the Period from October 1 to December 31, 1909: Inventory No. 21; Nos. 26048 to 26470."

This manuscript has been submitted by the Agricultural Explorer in Charge of Foreign Seed and Plant Introduction with a view to publication.

Respectfully,

G. H. POWELL,
Acting Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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SEEDS AND PLANTS IMPORTED DURING THE PERIOD FROM OCTOBER 1 TO DECEMBER 31, 1909: INVENTORY NO. 21; NOS. 26048 TO 26470.

INTRODUCTORY STATEMENT.

Although our agricultural explorer Mr. Frank N. Meyer has been in the field during the period covered by this inventory, the material received from him which is herein recorded is but a small part of the work performed by him. He has been investigating the prevalence of the crown-gall disease of the apple in France for the purpose of ascertaining whether the French have resistant stocks; making studies in the English, French, German, and Russian arboreta for the purpose of familiarizing himself with the important plants and plant cultures of Chinese Turkestan, which region it is expected he will explore this summer; and he has been unexpectedly delayed for six weeks in St. Petersburg. This office is negotiating by correspondence for the valuable material he has reported in the different arboreta.

To the fruit growers the question of better stock plants is of great importance and is being emphasized more strongly now than ever before. To such as are working on the problem, the introduction from Palestine, through Mr. Aaron Aaronsohn, of a large red-fruited variety of haw, *Crataegus azarolus* (Nos. 26116 and 26354), will be interesting. It has been used successfully both in Tunis and Palestine and is considered by Mr. Aaronsohn to be an ideal stock for dwarf early pears in our arid irrigated regions of the Southwest, where the question of growing early pears is attracting attention. A species of Photinia (No. 26133) from western China is sent in by Mr. Meyer, who suggests its use as a possible stock for the loquat.

The possibility of using the Chinese brambles for the production of new types of raspberries has been pointed out as promising. For those interested in this field, nine species of Rubus from the Yangtze Valley (Nos. 26270 to 26278), collected by Mr. E. H. Wilson, of the Arnold Arboretum, are likely to prove of very considerable interest.

The problem of growing in this country the large-fruited English gooseberry has proved difficult to solve because of the gooseberry mildew to which all English gooseberry varieties seem subject. Those interested in this fruit will be glad to test Dr. W. Van Fleet's three new hybrids between *Ribes missouriense*, *R. cynosbati*, and *R. rotundifolium* crossed by *R. reclinatum*. These represent twelve years of careful work in selection from hundreds of seedlings from various crosses, and preliminary tests have shown them remarkably resistant to the gooseberry mildew. (Nos. 26138 to 26140.)

Feijoa sellowiana (Nos. 26120 and 26121) is a new fruit from Uruguay which is attracting some attention in California and Florida, since it is said to withstand more cold than the guava and to have a unique flavor of its own which is especially relished by many. An acid-fruited species of *Psidium laurifolium* (No. 26413), from Trinidad, will interest those who believe in the future of the guava and its jelly-making qualities, since it is said to jelly much quicker than the common West Indian varieties and, quite distinct from them, to have an agreeable acidity.

To the Florida and California fruit growers who are watching the possibilities of the anonas, the introduction of eight large-fruited, smooth-skinned varieties from Chile will be of interest. (Nos. 26148 to 26155.)

The loganberry is already well known in the United States and those who realize its value will doubtless wish to test the lowberry (No. 26197) and Low's Phenomenal raspberry-loganberry hybrid (No. 26198), which are said to be new rivals of the loganberry.

Those who are experimenting with forage plants will be interested in a new importation of shaftal, *Trifolium suaveolens*, from Tashkend (No. 26135), a clover which is being given a thorough trial in the irrigated regions of the Southwest. Although normally an annual, this species behaves as a perennial if regularly cut for hay. The Wallaby grass, *Danthonia semiannularis*, from New Zealand (No. 26119), is recommended especially for heavy clay soils or gumbo lands subject to drought; and ray-grass, *Lolium strictum* (No. 26200), coming from the dry regions along the Mediterranean, is recommended by the veteran experimenter, Doctor Trabut, of Mustapha, Algiers, as being an excellent forage grass, an annual worthy of cultivation in the Southwest; while the New Zealand rice-grass, *Microlaena stipoides* (No. 26118), may find a use in America for pasture or lawn purposes.

Potato breeders have already shown an interest in the introduction of a few tubers of a species of Solanum thought to be a wild hybrid of *Solanum tuberosum* (No. 26122), which has been used by Mr. Paton, of Scotland, to originate what he believes are varieties practically immune to the potato blight, *Phytophthora infestans*. Interesting

varieties have also been introduced from Bogota, Colombia (Nos. 26126 to 26129).

The Arracacia of South America forms a staple food of the Venezuelans, who know it under the name of apio. It is cultivated in high altitudes and requires a long season in which to mature. It deserves a thorough trial in the South to determine where it will succeed. (No. 26204.)

The destructive fungous disease of the chestnut, which threatens to destroy the native chestnut trees of the Atlantic coast region, makes the production of a chestnut-chinquapin hybrid of unusual interest, since its resistance to this bark disease may furnish a way out of a situation which seriously threatens the chestnut industry. Doctor Van Fleet's hybrids (Nos. 26230 to 26235) have so far shown a high degree of immunity to the disease.

The interest in the Japanese flowering cherry trees, which have been found to succeed well in the United States, makes it worth while to call attention to seven Chinese flowering cherry trees from the Yangtze Valley, collected by Mr. E. H. Wilson, of the Arnold Arboretum. (Nos. 26246 to 26252.)

For many years attempts have been made to introduce the cliff-grown tea and the teas from the Dragon Pool, of the Kienningfu and Wuishan districts of China, but without success. Through the kind assistance of Mr. Rockhill, ambassador to Russia, formerly American ambassador to China, and the hearty cooperation of the American consul and vice-consul at Foochow, fourteen varieties of these specially noted teas have been introduced and are being propagated.

As heretofore, the work of identification and nomenclature, as well as that on the geographical distribution, has been done by Mr. H. C. Skeels under the supervision of Mr. W. F. Wight, of the Office of Taxonomic and Range Investigations, and the manuscript has been prepared by Miss Mary A. Austin.

DAVID FAIRCHILD,
Agricultural Explorer in Charge.

OFFICE OF FOREIGN SEED AND PLANT INTRODUCTION,
Washington, D. C., March 7, 1910.

INVENTORY.

26048 and 26049. Prunus spp.

From the Himalayas. Presented by Mr. E. Shearer, Assistant Inspector-General of Agriculture in India, Nagpur, Central Provinces, India. Received October 2, 1909.

Seeds of the following:

26048. Prunus armeniaca L. **Apricot.**

"*Shari.* A nursery of shari plants is prepared in January each year. The soil is first dug, properly cleaned, and manured; ditches are then made about 4 inches deep and the seeds are put in and covered with earth. These seeds germinate in the following March.

"These plants are then transplanted where desired in January next, i. e., after one year. They are planted in pits dug deep enough and are watered every second or third day until they take root in the ground. Shari plants when grafted with aru (peach) give a better variety of shari fruit." (*Shearer.*)

26049. Prunus sp. **Plum.**

"*Aloocha.* The season and process of sowing this seed are the same as that of shari (apricot) (S. P. I. No. 26048).

"Jamun (wild cherry) and aru (peach) when grafted on aloocha plants produce fine varieties of jamun and aru, respectively." (*Shearer.*)

26050. Aleurites trisperma Blanco. **Banucalag.**

From Philippine Islands. Presented by Mr. Elmer D. Merrill, Bureau of Science, Manila. Received October 2, 1909.

"As there are probably no live specimens of this species in America to-day, these seeds were procured to grow plants for trial in the tropical possessions of the United States. A portion of them will also be used for the expression of a sample of oil to be tested in the Bureau of Chemistry of the United States Department of Agriculture in Washington in comparison with oils derived from other species of Aleurites.

"This species, which yields a valuable drying oil, is found in the Philippines; so far as known, it is restricted to these islands and is comparatively rare but quite generally distributed. This plant is botanically known as *Aleurites trisperma* Blanco, but carries also the synonym *Aleurites saponaria* Blanco. It is known locally as 'banucalag,' 'lumbang banucalag,' 'lumbang banucalad,' 'baguilumban,' 'calumban,' or 'lumbang gubat,' besides having a variety of other names in the different provinces. It is much mixed and confused with the true lumbang (*Aleurites moluccana*), especially when information in regard to it is sought.

"*Aleurites trisperma* belongs to the same section of Aleurites as the Chinese and Japanese species; this may readily be seen by comparing the seeds and foliage of these three plants. The seeds resemble those of *Aleurites fordii*, while the leaves resemble those of *Aleurites cordata*. The seeds are somewhat larger, however, than those of the China wood-oil tree, besides being thicker shelled and of a distinct brick-red color." (*W. Fischer.*)

26051 to 26054. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

From Nanking, China. Presented by Dr. F. B. Whitmore. Received September 13, 1909. Numbered October 4, 1909.

Seeds of each of the following:

26051. Yellow.

26052. Yellowish green.

26053. Green.

26054. Black.

26055 to 26061. SACCHARUM OFFICINARUM L. **Sugar cane.**

Presented by Mr. Edward W. Knox, general manager of the Colonial Sugar Refining Company (Limited), Sydney, New South Wales, Australia. Received October 4, 1909.

Seeds of each of the following; notes by Mr. Knox:

26055. *Striped Singapore.* "Standard variety, medium thickness, medium quality. Very similar to Rose Bamboo, but striped amber and red."

26056. *Rose Bamboo.* "Standard variety, medium tonnage and sweetness, medium thickness, straw-rose color."

"These are at present most grown in the drier districts of Fiji, being of very fair weight and sweetness. According to Mr. J. Clark (one of our officers who recently paid a visit to Demerara and Barbados) Striped Singapore is the striped variant of the cane called White Transparent in the West Indies; Rose Bamboo is an allied cane which is very nearly identical with White Transparent, the latter being called Yellow Singapore in Fiji. The obvious difference between Rose Bamboo and Yellow Singapore is that the latter is somewhat thicker in the stalk and arrows very freely, while the former rarely flowers."

26057. *Badila.* "Best variety in Fiji and Queensland. Very heavy and very sweet, thick, purple."

26058. *Mohona.* "Early maturing, successful variety in New South Wales, but dies off early in the season in tropical Queensland and Fiji; rather thin, purple; white bloom."

"These have been obtained from New Guinea. Badila is a dark-purple cane of stout build, giving heavy and sweet crops under favorable conditions, but being a slow grower at the start. Mohona is of a lighter purple color, of medium size and yield, attaining high sweetness when comparatively young, readily going back in quality in the Tropics, but much more enduring in semitropical districts. It supplies very fertile seeds."

26059. *HQ. 10.* "Fairly sweet variety, fair tonnage, seedling raised from Mohona by Mr. J. Clark at Hambledon, Queensland. Thin, olive-green."

26060. *HQ. 50.* "Seedling raised from Mohona; rather thin, purple; white bloom; good cropper; good quality; raised at Hambledon, Queensland."

"These are both sweet and have given fair crops so far when tried on small areas only."

26061. *Couvé 87.* "This is a thick, purple Mauritius seedling, giving a heavy crop, which is somewhat discounted by shortcomings as regards quality. Seed from this variety is more fertile than that from any other known by us."

26062 to 26065. MUSA TEXTILIS Née. **Manila hemp.**

From Davao, Mindanao, Philippine Islands. Presented by Mr. M. M. Saleeby, in charge of fiber plants, Bureau of Agriculture, Manila, through Mr. Lyster H. Dewey. Received October 4, 1909.

26062 to 26065—Continued.

Seeds of each of the following:

26062. *Tanguyon* (also spelled *Tangouan* and *Tongongon*).

26063. *Libuton.*

26064. *Puteean.*

26065. *Arupan.*

"Mr. Saleeby, who is making a careful study of abacá (Manila hemp), writes that although abacá seedlings are often found in the fields in well-shaded moist places, he has never found good plants growing directly from the seeds. He suggests trying to grow plants from root cuttings or suckers from the seedlings that we may secure. He also states that he finds seedlings only in soil well drained yet constantly moist and constantly shaded. I would suggest that these seeds be grown with a view to sending the young plants to Porto Rico." (*Dewey.*)

26067. BETA VULGARIS L. **Beet.**

From Sicily. Presented by Dr. Carl Sprenger, Hortus Botanicus Vomerensis, Vomero, Naples, Italy. Received October 5, 1909.

Seed collected in a wild state.

26068. APIUM GRAVEOLENS L. **Celery.**

From France. Presented by Mrs. E. M. Sheridan, 2300 G street NW., Washington, D. C., who procured the seed from Vilmorin-Andrieux & Co., Paris, France. Received October 5, 1909.

Improved Paris celeri-rave (Falaise). "The taste of this is similar to the meat of the large artichoke and only requires boiling and a dressing of drawn butter gravy after it is cut in slices or small chunks." (*Sheridan.*)

"Sow in February or March in a bed under glass; set out in well-manured ground at a distance of 30 to 40 centimeters (12 to 16 inches). Harvest in August and September.

"Plant in nursery beds in April or May; set out in May or June. Gather in October or November and keep during the winter.

"A variety obtained by Mr. Falaise and distinguished from the common celeri-rave by a much greater development of the root. Foliage tolerably high with slender petioles, dark green, strongly tinted with red; the leaves themselves are large, tolerably serrate, of a dark and shining green, especially on the upper part of the stalk. It is the race most liked by the Parisian market gardeners; it is an improvement on Large Smooth Paris celeri-rave, which it has replaced and which was itself a good selection from Common celeri-rave." (*Vilmorin-Andrieux & Co.*)

26069. ARALIA CORDATA Thunb. **Udo.**

From New York, N. Y. Purchased from J. M. Thorburn & Co. Received October 7, 1909.

Kan. See Bureau of Plant Industry Bulletin 42 for description; also S. P. I. No. 9166.

26070 to 26077. MEDICAGO spp.

From Chico, Cal. Grown at the Plant Introduction Garden by Mr. Roland McKee. Received September 22, 1909.

Seeds of the following; descriptive notes by Mr. McKee:

26070. MEDICAGO HISPIDA CONFINIS (Koch) Burnat.

"This is a selection from S. P. I. No. 16771 made at Chico, Cal., in 1906. It is a prickleless form of bur clover and well adapted for pasturage, especially for sheep. It should be tested throughout the southern and southwestern United States. It has been grown for the increase of seed."

26070 to 26077—Continued.

Distribution.—The British Islands, France, Spain and Portugal, Italy, and the Balkan Peninsula.

26071. MEDICAGO HISPIDA NIGRA (L.) Burnat.

"Seed in the bur was received at the Plant Introduction Garden, Chico, Cal., in December, 1905, from the University of California. It perhaps will succeed wherever *M. hispida denticulata* or *M. arabica* does well. In California it is perhaps a little more aggressive than *M. hispida*. Of value for pasturage and soil improvement."

Distribution.—The European countries bordering on the Mediterranean Sea, including Spain, southern France, and Italy; also in the Balkan Peninsula, Asia Minor, Syria, Palestine, and northern Africa.

26072. MEDICAGO HISPIDA NIGRA (L.) Burnat.

Same as No. 26071.

26073. MEDICAGO HISPIDA Gaertn.

"Seed in the bur was received at the Plant Introduction Garden, Chico, Cal., in December, 1905, from the University of California. Of value for pasturage and soil improvement wherever common bur clover is adapted."

Distribution.—The Mediterranean region.

26074. MEDICAGO HISPIDA Gaertn.

Same as No. 26073.

26075. MEDICAGO HISPIDA TEREBELLUM (Willd.) Urban.

"Seed in the bur received at the Plant Introduction Garden, Chico, Cal., in December, 1905, from the University of California. This is practically a prickleless form of bur clover and needs to be tested extensively in the West and South for pasturage and soil improvement."

Distribution.—The countries along the Mediterranean, from Spain to Palestine and Egypt.

26076. MEDICAGO MURICATA (L.) All.

"This is a selection made from seed which was received at the Plant Introduction Garden, Chico, Cal., in December, 1905, from the University of California. It is a form of bur clover having a large but very hard bur. Should be tested in sections adapted to bur clovers."

Distribution.—The province of Riviera, southern France, and in Dalmatia, Croatia, and Herzegovina, southern Austria.

26077. MEDICAGO SCUTELLATA (L.) Miller.

"Seed in the bur was received at the Plant Introduction Garden, Chico, Cal., in December, 1905, from the University of California. This is a form of bur clover having a very large papery pod, making it especially desirable for pasturage. It should be tested in particular in the warmer sections of the South."

Distribution.—The Mediterranean region.

26078. CAPRIOLA INCOMPLETA (Nees) Skeels.

Cynodon incompletus Nees, Linnæa 7: 301. 1832.

The genus Capriola was established by Adanson in 1763, while Cynodon was not published until 1805, forty-two years later. Dactilon was proposed for the same genus by Villars in 1787 and Fibichia by Koeler in 1802.

From Pretoria, Transvaal, South Africa. Presented by Prof. J. Burtt Davy, government agrostologist and botanist, Transvaal Department of Agriculture. Received October 14, 1909.

"This is closely related to common Bermuda grass." (*C. V. Piper.*) (Roots.)

26078—Continued.

Distribution.—This species occurs in South Africa and was originally described from "Gaaup," in the district of Beaufort, Cape Colony. It has since been found in various localities from the vicinity of Lydenburg, Transvaal Colony, southward, and westward to the banks of Orange River in Little Namaqualand. In the central region of Cape Colony it is found at elevations of 3,000 feet.

26109. ZIZYPHUS SATIVA Gaertn. **Chinese date.**

From Chekiang Province, China. Presented by Mr. J. H. Judson, Hangchow, China. Received April 21, 1908. Numbered October 6, 1909.

"I can not say whether these plants are of a named variety or not. The Chinese have three kinds on the market, which they call red, black, and honey dates." (*Judson*.)

26110 and 26111.

From Beirut, Syria. Presented by Mr. A. E. Day, professor of natural science, The Syrian Protestant College. Received October 8, 1909.

Seeds of each of the following:

26110. CUCURBITA PEPO L.

"*Kusa*." See No. 22810 for description.

26111. CUCUMIS SATIVUS L. **Cucumber.**

"We eat freely of this cucumber, and it is a common sight to see a Syrian child one or two years old chewing away at one; it does not seem to hurt them." (*Day*.)

26112. DIOSPYROS DISCOLOR Willd. **Mabola fruit.**

From Philippine Islands. Presented by Mr. William S. Lyon, Gardens of Nagtajan, Manila. Received October 11, 1909.

"A small tree, native of the Philippine Islands, introduced into India and cultivated in gardens, especially in Vizagapatam. The fruit is like a large quince and in some places is called mangosteen; its proper name should be the *Mabola* fruit. It is agreeable and has a pink-colored fleshy rind." (*Extract from Watt, Dictionary of Economic Products of India, vol. 3, p. 138*.)

See No. 19216 for previous introduction and description.

26115. MUCUNA GIGANTEA (Willd.) DC.

From Buntal, at the mouth of Sarawak River, Sarawak, Borneo. Presented by Mr. J. C. Moulton, curator, Sarawak museum. Received October 12, 1909.

Black. See No. 25514 for distribution.

26116. CRATAEGUS AZAROLUS L.

From Zichron-Jacob, near Haifa, Palestine. Presented by Miss Rifka Aaronsohn, through Mr. A. Aaronsohn. Received October 4, 1909.

"Arabian name za'arur. This species is very abundant throughout the Orient, where a great many varieties and forms of it are found. It grows wild on the slopes of dry, arid hills, preferably amongst calcareous rocks. It is a shrub with spiny branches from 1.5 to 4 or 5 meters in height, with a diameter of 10 to 30 centimeters. It is rather a slow grower.

"In the spring it bears dense corymbs of white flowers which are pleasantly fragrant. The size of the fruits varies in different varieties. Some have fruits as large

26116—Continued.

as 1 inch in diameter. The acid flesh has a delicate flavor, but there is not enough of it to give the fruits a commercial value. Fruits are occasionally found, however, that are practically without seeds and it might be possible to fix this character by selection. As it is the fruit is often sold in the oriental markets.

"I particularly recommend this Crataegus as a stock for pears. It is good for dry localities at any altitude. It is found as low as 200 meters below the level of the Mediterranean in the valley of the Jordan and as high as 1,800 meters above sea level in the desert near Petra. It ought, therefore, to thrive in southern California as well as on the plateaus of Colorado.

"My personal experience has shown that a top graft 6 inches or a foot above the ground is the best for this stock. It is best suited for the early varieties of pears.

"I recommend this as a stock, therefore, in high, arid situations where water is scarce or costly. It is an ideal stock for dwarf early pears. At Indio, Cal., for instance, it ought to yield prime fruit with very little irrigation.

"Palestine (where my father has had trees grafted in this way for 18 years) is not the only region in which *Crataegus azarolus* has been used as a stock for the pear. Mr. Dumont has used it for the same purpose near Tunis.

"I speak of pears because I have had personal experience with this fruit. But I can see no reason why it would not do as well as a stock for dwarf early apples." (*A. Aaronsohn.*)

Distribution.—A native of southern Europe, western Asia, and northern Africa, being found in Spain, Italy, Crete, Caucasia, Asia Minor, Syria, Palestine, Arabia; Persia, and Algeria.

26117. Medicago sativa L. — Alfalfa.

From Indian Head, Saskatchewan, Canada. Presented by Mr. Angus Mackay, superintendent, Dominion Experimental Farm for Saskatchewan, through Mr. Charles J. Brand. Received October 18, 1909.

Grimm.—"Grown at Indian Head from S. P. I. No. 12991; seeded in comparison with eight other strains in the spring of 1905. No. 12991 was produced in Minnesota in 1904 and was secured from Mr. A. B. Lyman, Excelsior, Minn. In the Indian Head experiments it has proven from the first (1905 to 1909) to be the best of the nine strains under test." (*Brand.*)

26118 and 26119.

From Wellington, New Zealand. Presented by Mr. T. W. Kirk, Biologist, Department of Agriculture. Received October 18, 1909.

Seeds of the following:

26118. Microlaena stipoides (Labill.) R. Br. **New Zealand rice-grass.**

A native grass, much relished by all kinds of stock; the herbage is of a rich green color, and is produced in great abundance.

Distribution.—A native of New Zealand and Australia, where it is widely distributed and used for a lawn and pasture grass.

26119. Danthonia semiannularis (Labill.) R. Br. **Wallaby grass.**

A grass which does well on any of the poorer classes of gumbo land, also on heavy clay soils. It stands drought with impunity, and throws up a good quantity of feed, which is eaten by all classes of stock.

See No. 21024 for previous introduction.

Distribution.—New Zealand, Tasmania, and the temperate parts of Australia.

26120 and 26121. FEIJOA SELLOWIANA Berg.

From Los Angeles, Cal. Presented by Mr. H. Hehre. Received October 11, 1909.

Seeds of the following:

26120. "These fruits were raised from a plant imported by me from Europe a number of years ago and which has been bearing regular crops for five or six years." (*Hehre.*)

26121. "These fruits are from a plant originated by me from seed imported from Europe; it has not been named. Ripens later than the preceding variety." (*Hehre.*)

"*Feijoa sellowiana* is worthy to be mentioned under promising new fruits and deserves the widest distribution. The plant stands more cold than the guava, is beautiful in bloom, and is evergreen. The fruit is green and when ripe has a tinge of yellow. As it blooms for a period of about two months, so does the fruit ripen successively for two months; therefore there are all sizes of fruit on the plant at the same time, which grow at the leaf axil on new wood." (*Hehre.*)

Distribution.—Found in the province of Rio Grande do Sul, in the southeastern part of Brazil, and in the vicinity of Montevideo, Uruguay; cultivated in southern Europe.

26122. SOLANUM sp. **Potato.**

From Castle Kennedy, Scotland. Presented by Rev. J. Aikman Paton, Soulseat. Received October 19, 1909.

"Tubers of *Solanum etuberosum* (so called; I think it is a wild hybrid of *S. tuberosum*, simply), which I used as the parent of my 'Immune' strain. A certain proportion of the 'selfed' seedlings of it and its hybrids are immune to *Phytophthora infestans* even here." (*Paton.*)

26123. CITRUS BERGAMIA Risso. **Bergamot orange.**

From Nice, France. Presented by Dr. A. Robertson Proschowsky. Received October 20, 1909.

Variety *mellarosa plena*. (Cuttings.)

26124. TRIFOLIUM SUBROTUNDUM Steud. & Hochst.

From 70 miles east of Lake Victoria Nyanza, British East Africa, at about 7,500 feet altitude. Presented by Mr. E. Blackbun, Salem, Ohio. Received October 19, 1909.

Distribution.—A native of Abyssinia, where it is cultivated as forage, under the name of Mayad; also native of Upper and Lower Guinea.

26125. MANGIFERA INDICA L. **Mango.**

From Port of Spain, Trinidad, B. W. I. Presented by Mr. F. Evans, Department of Agriculture. Received October 19, 1909.

Julie. "This plant is grafted upon the common mango, *Mangifera indica.*" (*Evans.*)

See No. 21515 for description.

26126 to 26129. SOLANUM spp. **Potato.**

From Bogota, Colombia. Presented by Mr. Eugene Betts, American vice and deputy consul-general. Received October 18, 1909.

Tubers of the following; quoted notes received with the shipment:

26126. "*Pápas Tocanas.* Produced on high, broken ground, mountain sides, high and very cold."

26126 to 26129—Continued.

26127. "*Pápas Arrayanas, criallas coloradas.* Produced on the mountain tops and on high table lands."

26128. "*Pápas Paramunas.* Produced on the mountain slopes above the Savannah of Bogota."

26129. "*Pápas Amapalá.* Produced on the Savannah of Bogota."

26130. MEDICAGO SATIVA L. **Alfalfa.**

From Talas, Caesarea, Turkey. Presented by Dr. Wm. S. Dodd, through Mr. Charles J. Brand. Received October 19, 1909.

"In his letter transmitting this seed Doctor Dodd states: 'I am not sure whether the lucern for which you ask is the plant that we cultivate here for horse feed or not, but I send some of that. Yonja is the Turkish name.' Only a small package of this seed was received, and it should be reserved for experiments in the Southwest." (*Brand.*)

26132 and 26133.

From Mr. Frank N. Meyer, Agricultural Explorer. Received October 13, 1909.

Seeds of the following:

26132. PRUNUS sp.

From China. Obtained at the M. L. de Vilmorin Arboretum, Les Barres, Nogent sur Vernisson, France.

26133. PHOTINIA VILLOSA (Thunb.) DC.

From Western China. Obtained at the M. L. de Vilmorin Arboretum, Les Barres, Nogent sur Vernisson, France. "This plant has a rather dwarfy habit, is apparently evergreen in a climate not too cold, and may serve as a stock for loquats, besides being also ornamental. The plant will probably not be hardy in Washington, D. C." (*Meyer.*)

Distribution.—A native of the southeastern provinces of the Chinese Empire and of Formosa, and widely distributed in Japan.

26134. ALLIUM CEPA L. **Onion.**

From Denia, Spain. Procured from Señor Don Luis Tono, American consular agent, through Mr. Robert Frazer, jr., American consul, Valencia, Spain. Received October 20, 1909.

"Seed of the onion that is commercially grown on an extensive scale in Denia. These onions come upon the American market in a peculiar type of package and are the large yellow or straw-colored onions which are sold under the name of Spanish onions. The closest American representative of this type is the Prizetaker, which I understand is an American sport from this variety. It is probably the largest of the onions which are grown extensively for market, has the thinnest skin, is the mildest in flavor, and altogether is the best onion produced in the world. From imported seed we have succeeded in producing some very fine specimens in parts of Texas, and we hope that from this small beginning a very considerable industry will be built up. The probabilities are that we shall always need to import the seed direct from Spain in order to maintain the high quality in the American-grown product." (*L. C. Corbett.*)

26135. TRIFOLIUM SUAVEOLENS Willd. **Shaftal, or schabdar.**

From Tashkend, Turkestan. Purchased from Dr. Richard Schröder, director Chief Agricultural Experiment Station, at the suggestion of Prof. N. E. Hansen, Agricultural Experiment Station, Brookings, S. Dak. Received October 23, 1909.

26135—Continued.

The following notes were taken from a letter written by Doctor Schröder to Professor Hansen; clause in brackets is by Professor Hansen:

"In Persia the schabdar seed is usually sown in the fall, not too late. It endures the winter quite well. By sowing in the fall it develops in the spring so quickly that the first cutting is ready before the first cutting of alfalfa. According to information obtained in Persia the schabdar endures several years. This lot is of a new variety which endures from five to seven years. The fact that this plant is perennial comes in conflict with botanical statements [that it is an annual].

"In Persia the fresh shoots of the schabdar are also used for salad. The flowers are visited by bees."

26136. GOSSYPIUM BARBADENSE L. **Cotton.**

From Nyassaland Protectorate, British Central Africa. Presented by Mr. J. Stewart J. McCall, director of agriculture, Zomba. Received October 23, 1909.

"*Egyptian* (*Abbasi*). Our Egyptian is not nearly so good as our Upland cotton (S. P. I. No. 25964)." (*McCall.*)

26137. FRAGARIA sp. **Strawberry.**

From Germany. Presented by Rev. J. M. W. Farnham, Chinese Tract Society, Shanghai, China. Received September 13, 1909

White fruited. (Seed.)

26138 to 26140. RIBES hybrids. **Gooseberry.**

From Little Silver, N. J. Presented by Dr. W. Van Fleet. Received October 22, 1909.

Plants of the following; quoted notes by Doctor Van Fleet:

26138. RIBES MISSOURIENSE × RECLINATUM.

"Third generation. (*R. gracile* (*R. missouriense*) × *Red Warrington* × *Triumph* × *Keepsake*.) Six-year-old plant, very vigorous, 6 feet high, disease-resistant foliage, productive, berries dark reddish-purple when ripe, smooth, thin skinned, larger than Houghton, excellent quality, seeds small."

26139. RIBES CYNOSBATI × RECLINATUM.

"Second generation. (*R. cynosbati* × *Triumph* × *Whitesmith*.) Fair grower; rather spreading; good, disease-resistant foliage; berries large, dark red when ripe, few soft spines, very firm, agreeable flavor, small seeds; excellent for jelly."

26140. RIBES ROTUNDIFOLIUM × RECLINATUM.

"Third generation. (*R. rotundifolium* × *Houghton* × *Triumph* × *Keepsake*.) Healthy, upright grower; disease-resistant foliage; berries rather small, smooth, bright red when ripe, brisk, pleasant quality, exceedingly productive."

"These hybrids are final selections from hundreds of seedlings, representing 12 years of arduous work."

NOTE.—"Houghton is supposed to be *R. oxycanthoides* × *grossularia* (*reclinatum*)."

26141 and 26142.

From Pretoria, Transvaal, South Africa. Presented by Mr. F. T. Nicholson, secretary, Transvaal Agricultural Union. Received October 25, 1909.

26141. VICIA FABA L. **Horse bean.**

Light brown seeded. (Seed.)

26142. GLADIOLUS sp. (Bulbs.)

26143 and 26144.

From the Himalayas, India. Presented by J. Mollison, esq., Inspector-General of Agriculture in India. Received October 26, 1909.

Seeds of the following:

26143. Malus sylvestris Mill. **Crab apple.**

"*Pala* (*Palu*) is generally propagated by cuttings. When grown from seeds, the method of raising the plants is as follows: In the month of January, the plat to be sown is dug about one-half foot deep and is manured. Then the seeds are sown and germinate in the following summer.

"In January next (i. e., a year after), the plants are transplanted, where desired, in pits dug for that purpose. Pala is only grafted on seb (apple). It is also grafted with nashpati (pears), but the pears produced are sour." (*Mollison.*)

26144. Prunus padus L.

"*Jamu.* The process of cultivating jamu is the same as that of pala (S. P. I. No. 26143).

"This plant is grafted with aloocha (plum) (S. P. I. No. 26049) and yields aloocha fruit. If it is grafted on aloocha plant, jamu fruits will be produced." (*Mollison.*)

26145 and 26146. Andropogon sorghum (L.) Brot. **Durra.**

From Igatpuri, India. Presented by Mrs. Effie Pyle Fisher, through Miss Audrey Goss. Received August 31, 1909.

Seeds of the following; notes by Mr. Carleton R. Ball:

26145. "Apparently very similar to No. 9856, Dagdi durra, which we are selecting for grain production, and which now gives considerable promise of value for the Southwest."

26146. "A white durra with black hulls, probably a late sort."

26147. Citrus aurantium sinensis L. **Orange.**

From Mount Gravatt, Brisbane, Australia. Presented by Mr. John Williams. Received October 28, 1909.

"*Usher's Favorite.* It ripens in October here, and is a splendid keeper; quality, flavor, and all things considered, I believe it to be really first class." (*Williams.*)

(Plants.)

26148 to 26155. Anona cherimola Mill. **Cherimoyer.**

From Santa Inez, Chile. Presented by Mr. Salvador Izquierdo. Received October 26, 1909.

"Nos. 26148, 26152, 26153, 26154, and 26155 are different cherimolas with very large fruits, of the form 'ananas.' No. 26149 is a very large cherimolia with smooth skin. Nos. 26150 and 26151 are large-fruited cherimolias, smooth skin, form 'concha.'" (*Izquierdo.*) (Cuttings.)

26156 to 26160.

From Foochow, China. Presented by Mr. Samuel L. Gracey, American consul. Received October 25, 1909.

Seeds of the following:

26156 to 26158. Citrullus vulgaris Schrad. **Watermelon.**

26156. "White or Shanghai melon, very popular in this district." (*Gracey.*)

26156 to 26160—Continued.

26156 to 26158—Continued.

26157. Yellow. **26158.** Red.

26159 and 26160. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

26159. Yellow seeded. **26160.** Green seeded.

26161. MEDICAGO SATIVA L. **Alfalfa.**

From different oases in the region of Ourlana and Tougourt, Algeria. Purchased from M. Colombo, père, Biskra, Algeria, at the request of Mr. Walter T. Swingle. Received October 29, 1909.

26162 to 26178.

Presented to Mr. P. J. Wester, Subtropical Garden, Miami, Fla., and turned over by him to this office for distribution, October, 1909.

Seeds (unless otherwise noted) were received of the following; notes by Mr. Wester:

26162 to 26174. Presented by Mr. J. M. Doctor, acting superintendent, Victoria Gardens, Bombay, India.

26162. ACACIA ARABICA (Lam.) Willd.

"The gum arabic.. An evergreen shade tree with dense and spreading crown, attaining a height of 60 feet; valuable for its gum, bark, and timber; the pods are a favorite food for sheep and goats. The tree thrives on a great variety of soils and is resistant to droughts."

Distribution.—Widely distributed, being found in India, Ceylon, Egypt, Arabia, tropical Africa, and Natal.

26163. ACACIA sp.

26164. BARRINGTONIA ASIATICA (L.) Kurz.

"An ornamental, lecythidaceous, evergreen shrub, attaining a height of 6 to 8 feet; cultivated as an ornamental on account of its shining foliage and large, handsome purple and white flowers produced on an erect thyrse."

Distribution.—Found along the shores of southern India, and of Australia, and on the islands between.

26165. BAUHINIA ACUMINATA L.

"A leguminous ornamental shrub, 6 to 8 feet tall, native of Malabar, bearing white flowers."

Distribution.—India, especially in the northwestern part, and extending to Ceylon, China, and the Malayan Islands.

26166. THESPESIA LAMPAS (Cav.) Dalz. and Gibs.

Distribution.—The tropical Himalayas of India, from Kumaon eastward, and in Bengal, Burma, and Ceylon; also found in Java and in eastern tropical Africa.

26167. BUTEA MONOSPERMA (Lam.) Taub.

"Leguminous, native of India. An ornamental shade tree with dense foliage, attaining a height of 40 to 50 feet. The flowers are very showy, crimson, 2 inches long."

Distribution.—Found throughout the plains of India, from the Himalayas to Ceylon and Burma.

26162 to 26178—Continued.

26162 to 26174—Continued.

26168. CASSIA AURICULATA L.

"A shrub or small tree, native of India, the bark of which yields tannin. In young plants the bark has been found to contain 11.92 tannin and 22.35 extract; in old plants the corresponding figures are 20.12 and 29. In India the leaves are used as a substitute for tea and eaten as a vegetable in times of famine. This is also cultivated for its ornamental value. The yellow flowers appear in June and July."

Distribution.—Wild in the western and central part of India and in Ceylon; often cultivated in the Tropics.

26169. CASSIA GLAUCA Lam.

"A tall leguminous tree."

Distribution.—From the Himalayas, in India, through Ceylon and the Polynesian Islands to Australia.

26170. CASSIA GRANDIS L. f.

"A tree attaining a height of 45 to 55 feet furnishes a very handsome fine-grained wood. A dense shade tree, flowers very handsome, appearing in April."

Distribution.—The northern part of South America, from Panama, through Colombia and Guiana, to Brazil; also found in the West Indies.

26171. CAESALPINIA CORIARIA (Jacq.) Willd.

See Nos. 23335 and 25281 for previous introductions.

26172. PITHECOLOBIUM DULCE (Roxb.) Benth.

"A tree of very rapid growth, deserving wider distribution." See No. 23457 for description.

26173. FICUS BENGHALENSIS L. **Banyan tree.**

"In tropical India and Africa this tree attains a height of 70 to 100 feet. The aerial roots descending from the branches form accessory trunks, thus extending the growth of the tree from the main stem. The leaves are eaten by cattle. In India the fruits are eaten in time of famine. The wood, if carefully cut and seasoned, can be made into furniture and is sometimes employed in making boxes and door panels. The Hindoos regard the tree as sacred. The one tree in southern Florida that has come to my attention does so exceedingly well that the species deserves wider distribution."

Distribution.—Found wild in the lower Himalayan forests and on the Deccan hills; cultivated throughout India on the plains.

26174. FICUS CANNONII (Bull.) N. E. Brown.

"An ornamental-leaved greenhouse plant from the Society Islands. With the exception of the cultivated fig all species of Ficus introduced to southern Florida, as far as they have come to my attention, do so exceedingly well that I have thought it well worth while to introduce all species that are cultivated in other parts of the world in the hope of finding a suitable stock for the fig, which does not do well on its own roots here, largely on account of root-knot."

26175 to 26178. Presented by Mr. A. S. Archer, Antigua, British West Indies.

26175. THRYALIS GLAUCA (Cav.) Kuntz.

"An ornamental shrub bearing yellow flowers, Malpighiaceae."

26162 to 26178—Continued.

26175 to 26178—Continued.

Distribution.—Mexico and Central America, from Sierra Madre and Zacatecas, south to Nicaragua.

26176. HAEMATOXYLUM CAMPECHIANUM L. **Logwood.**

"Leguminous. The tree furnishes the logwood of commerce and the wood may be utilized in turning. The honey produced from the flowers of this species is said to be the finest in the world. The tree attains a height of 30 to 45 feet."

Distribution.—Central America, from Tehuantepec and Yucatan to Nicaragua and Colombia; also West Indies.

26177. BOUSSINGAULTIA BASELLOIDES H. B. K.

"A rapid-growing half-hardy ornamental climber. The flowers on opening are white and fragrant, turning black before withering. Easily propagated from tubers growing on the stem."

Distribution.—Southern Mexico and South America, from Gonacatepec south to southern Brazil.

26178. CEDRELA ODORATA L.

"Indigenous to the West Indies; attains a height of 80 feet. The wood is light, of pleasant odor, and easily worked, preferentially chosen in its native country for cigar boxes and a variety of other articles; also furniture."

26179 to 26182.

From Tripoli, in Barbary, North Africa. Presented by Mr. William Coffin, American consul. Received October 28 and November 1, 1909.

Seeds of the following; descriptive notes by Mr. Coffin:

26179. HORDEUM VULGARE L. **Barley.**

Dry land.

26180. PENNISETUM AMERICANUM (L.) Schum. **Pearl millet.**

"*Kassab.* The Arabs think very highly of this grain as a food and use the grass as fodder for their stock."

26181. MEDICAGO SATIVA L. **Alfalfa.**

"*Safsafa* or *Susfa.* Sometimes they get eight crops of this in the eight months of the year it grows. I have seen at least five, and I think six, crops harvested from fields just back of my house. They irrigate about every four days."

26182. CITRUS AURANTIUM SINENSIS L. **Orange.**

Blood flesh. (Plants.)

26183. STIZOLOBIUM sp.

From Sibpur, near Calcutta, India. Presented by Maj. A. T. Gage, director, Royal Botanic Garden. Received November 2, 1909.

Black seeded.

26184. FUNTUMIA ELASTICA (Preuss) Stapf.

Presented by Mr. Gilbert Christy, F. L. S., care of Thomas Christy & Co., 4, 10, and 12 Old Swan lane, Upper Thames street, E. C., London, England. Received December 2, 1909.

"Seeds of a very large forest tree. I suggest that you have them planted in one of the Cuban stations. It would be necessary to shade the growing seedlings in the summer, otherwise they would be likely to dry off." (*Christy.*)

26184—Continued.

Distribution.—Along the west coast of Africa from the Gold Coast in Ashanti through Lagos and lower Nigeria to the valley of Mungo River; usually in forests and along streams.

26185. STIZOLOBIUM sp.

From Tehwa, via Foochow, China. Presented by Miss Jessie A. Marriott. Received December 3, 1909.

"This species has pods about intermediate in character between the Lyon bean, No. 19979, and the Yokohama, No. 25254. To judge from its behavior in the greenhouse, it is about intermediate in time of maturity between these two species. The flowers are white as in the Lyon bean; very similar to the Japanese variety." (*C. V. Piper.*)

26186 and 26187.

From Nice, France. Presented by Dr. A. Robertson Proschowsky. Received November 2, 1909.

26186. FURCRAEA BEDINGHOUSI K. Koch.

"This plant is said (like most Furcraea, I suppose) to produce good fibers. This species is hardier than any other Furcraea I cultivate or know, and has once resisted from 5 to 7 degrees below zero Centigrade, without suffering the least. A few seeds were also produced on the 6-meter-high flower stalk." (*Proschowsky.*)

Distribution.—On the slopes of Acusca Mountain, south of the city of Mexico, at an elevation of about 12,000 feet. (Bulbs.)

26187. MAYTENUS BOARIA Molina.

See No. 3394 for description.

Distribution.—Dry lowlands along the coast of Chili and southward into Patagonia. (Seeds.)

26188. KAEMPFERIA sp. **"Sherungulu."**

From Transvaal, South Africa. Presented by Prof. J. Burtt Davy, government agrostologist and botanist, Transvaal Department of Agriculture, Pretoria. Received November 5, 1909.

"This plant grows in tropical and subtropical Transvaal and the tubers or rhizomes are dried and sent up from the Low Country, for sale to natives working on the Witwatersrand, by whom they are supposed to have medicinal or other virtues.

"It has been suggested that owing to the remarkable fragrance of the tubers, they might possibly be of use in the perfume trade for scenting tooth powders, soaps, etc.

"The flowers are distinctly ornamental." (*Davy.*) (Tubers.)

26189. CHRYSANTHEMUM HYBRIDUM Hort. **Shasta daisy.**

From Rosedale, Santa Cruz, California. Presented by Mr. George J. Streator. Received November 4, 1909.

"Streator's strain of the so-called Shasta daisy. Seed from the finest semidouble, quilled, fimbriated, or fringed forms." (*Streator.*)

26193 to 26195.

From Mexico. Procured by Dr. David Griffiths, Agriculturist, of this Department. Received November 5, 1909.

26193 to 26195—Continued.

Seeds of each of the following:

26193 and 26194. Cicer arietinum L. **Chick-pea.**

26193. Small seeded. **26194.** Large seeded.

26195. Physalis ixocarpa Brot. **Husk tomato.**

"This big blue husk tomato is often 4 centimeters in diameter, as found upon the markets of Oaxaca and Mexico City especially."

Distribution.—Found wild in California, Colorado, New Mexico, Texas, Mexico, and Cuba; cultivated, and often escaped, as far north as Massachusetts, Michigan, Dakota, Oregon, and Washington.

26196. Saccharum officinarum L. **Sugar cane.**

From Honolulu, Hawaii. Presented by Mr. Harold L. Lyon, Experiment Station of the Hawaiian Sugar Planters' Association. Received November 2, 1909.

Lahina. "This cane has proved itself to be the best money maker that Hawaii ever saw. Under irrigation it is a splendid cane if the conditions are suited. Unfortunately it is a cane that is very subject to disease. In those parts of Hawaii where it can still be used, namely, those parts where the sky is nearly cloudless the year around and the rainfall very slight, it still does better than any other cane. If any attempt to introduce this cane to other places from Hawaii is made, great care should be exercised to select cuttings free from disease." (*N. A. Cobb, letter of May 22, 1909.*) (Cuttings.)

26197 and 26198. Rubus spp.

From Enfield, England. Purchased from Messrs. Stuart Low & Co., Royal Nurseries, Bush Hill Park, at the request of Mr. Walter T. Swingle. Received November 4, 1909.

Plants of the following:

26197.

"*Lowberry.* This is said to be as large as the loganberry and to be as strong a grower, and to be 'altogether the most valuable novelty in the fruit way produced for some years.'" (*Swingle.*)

26198.

"*Low's Phenomenal.* A raspberry-loganberry hybrid, 'possessing all the flavor of the raspberry, and combining the free fruiting qualities of this now famous berry.'" (*Swingle.*)

26199. (Undetermined.)

From Standerton, Transvaal. Presented by Mr. O. W. Barrett, director of agriculture, Lourenço Marquez, Portuguese East Africa. Received November 8, 1909.

"Seeds of a striking asclepiad. This vine is probably native to the locality. Foliage not seen. Stems, thickish, green. Fruits (follicles) about 4 inches long, opening to about 3 inches wide. Ornamental and ought to make a good trellis or porch vine for the Southern States and California." (*Barrett.*)

26200. Lolium strictum Presl.

From Sfax, Tunis. Presented by Doctor Trabut, Algiers, Algeria. Received November 8, 1909.

"Seed of ray-grass, native name *maudjour.* Excellent forage; grows in arid regions; annual; interesting to cultivate in the steppes." (*Trabut.*)

26200—Continued.

Distribution.—The countries bordering on the Mediterranean Sea and the Canary Islands.

26201 and 26202.

From 30 miles north of Hangchow, China. Presented by Rev. J. M. W. Farnham, Presbyterian Mission, Shanghai, China. Received November 2, 1909.

Seeds of the following:

26201. CUCUMIS MELO L. **Muskmelon.**

Golden.

26202. SILENE sp. **Wild pink.**

"Found on the mountain here." (*Farnham.*)

26203 to 26206.

Presented by Mr. H. F. Schultz, Ancon, Canal Zone, Panama. Received November 9, 1909.

26203. ANONA SQUAMOSA L.

From David, Chiriqui, Panama. "Seed from a tree bearing large and very superior fruits of fine flavor." (*Schultz.*)

26204. ARRACACIA sp. **"Aracache."**

From Boquete, Chiriqui, Panama. "Tubers of a plant found growing in the neighborhood of Boquete in a cultivated and semicultivated state. The tubers grow to a size of 6 to 15 inches in length and about 6 to 8 inches in diameter, weighing from 2 to 10 pounds. The foliage resembles somewhat that of celery, and it grows to a height of about 10 to 18 inches above the ground. The taste of the root resembles a cross between a potato, celery, and asparagus, and it is eaten like potatoes, roasted, baked, or fried, as well as cut up in soups. I have found it growing at an altitude of 3,000 to 5,000 feet above sea level, and the inhabitants claim that it will not grow on the lower levels. I think, however, that it will do well in the Gulf States and that it will prove valuable, as I know that it is a well-flavored vegetable." (*Schultz.*)

See S. P. I. No. 3511 for previous introduction.

26205. BYRSONIMA COTINIFOLIA H. B. K.

From Chiriqui, Panama. "Seeds of a fruit called 'Nance' which is used by the inhabitants as the main ingredient for a cooling and very pleasing drink. This tree is found growing at all altitudes from sea level up to about 4,000 feet and above. I do not think that it is a very valuable tree. It may possibly succeed in southern California." (*Schultz.*)

Distribution.—Along the Pacific coast of Mexico, from the province of Tepic to Chiapas.

26206. PARMENTIERA CEREIFERA Seem.

From Bugaba, Panama. "Seed of an ornamental tree with peculiarly shaped candle-like fruits produced in great abundance on the second year's growth of the plant. The long, smooth, yellow fruits are 8 to 20 inches long and one-half to three-fourths of an inch in diameter, containing in the strong, fibrous, fleshy pulp numerous small flat seeds. The inside of the fruit has a strong musky fragrance, and the appearance of the bushy, spreading shrub, which grows to a height of about 12 to 15 feet, with its numerous candle-like fruits, is quite odd. The fruits were obtained on the ranch of Mr. Alexander Croetsch, of Bugaba, province of Chiriqui, and flowers were not in evidence." (*Schultz.*)

Distribution.—Confined to the valley of Chagres River, Republic of Panama.

26207. PROTEA MELLIFERA Thunb.

From Durban, Natal, South Africa. Presented by Prof. J. Medley Wood, director, Botanic Gardens. Received November 8, 1909.

A South African bush, useful both as an ornamental and as a bee plant.

26208. SOLANUM TUBEROSUM L. **Potato.**

From Solomon, Alaska. Presented by Mr. T. Brown. Received October 14, 1909.

"Tubers round to oblong, flattened; skin deep flesh color; eyes few and shallow." (*W. V. Shear.*)

26209 to 26223. CITRUS spp.

From Sawbridgeworth, Herts, England. Purchased from Thomas Rivers & Son, at the request of Mr. Walter T. Swingle. Received November 11, 1909.

Plants of the following:

26209 to 26219. CITRUS AURANTIUM SINENSIS L. **Orange.**

26209 to 26216. Subvarieties of the St. Michael's orange, which is said to be the ordinary orange of commerce, and although some of the strains have been tried in this country it was thought desirable to introduce the following:

26209.	*Long.*	26213.	*Dom Louise.*
26210.	*Botelha.*	26214.	*Egg.*
26211.	*Bittencourt.*	26215.	*Excelsior.*
26212.	*Nonpareil.*	26216.	*Dulcissima.*

26217. *White.* "Very distinct, with striped fruit and white pulp; flavor very good." (*T. Rivers & Son.*)

26218. *Embigus* (Navel).

"A singular variety, with a nipple-like excrescence at the apex; fruit large and good; pulp pale in color." (*T. Rivers & Son.*)

26219. *Silver* (Plata). "A delicious orange." (*T. Rivers & Son.*)

26220 and 26221. CITRUS LIMETTA Risso. **Lime.**

26220. *Common.* "An abundant bearer; fruit excellent for cooling drinks." (*T. Rivers & Son.*)

26221. *Bitter.* "Remarkable for the great fertility and dwarf habit of the tree; resembles the Bijou lemon so closely as to be distinguished with difficulty except by the color of its fruit." (*T. Rivers & Son.*) See No. 26222.

26222 and 26223. CITRUS LIMONUM Risso. **Lemon.**

26222. *Bijou.* "Pronounced to be a lime by some authorities. Fruit small, with a delicious aroma; growth of the tree very dwarf and fruitful; this is a remarkable sort." (*T. Rivers & Son.*) See No. 26221.

26223. *White.* "One of the largest and best." (*T. Rivers & Son.*)

26224. CARICA PAPAYA L. **Papaw.**

From Puerto Plata, Dominican Republic. Presented by Mr. A. W. Lithgow, American vice-consul. Received November 12, 1909.

"Native name 'lechosa,' the only class known here." (*Lithgow.*) (Seeds.)

26225 to 26227. CITRULLUS VULGARIS Schrad. **Watermelon.**

From Bucharest, Roumania. Presented by Mr. William G. Boxshall, vice consul-general, through Mr. Horace G. Knowles. Received November 13, 1909.

Seed of the following small melons:

26225. Red flesh. **26227.** Red flesh.
26226. Yellow flesh.

26228 and 26229. AVENA SATIVA L. **Oat.**

From Feuchtwangen, Germany. Purchased from Mrs. Sophie Kreiselmeyer. Received April 20, 1909. Numbered for convenience in recording distribution November 15, 1909, at which time definite information regarding this shipment was received.

Seed of the following:

26228. *Giant of Ligowa.* **26229.** *Fichtelgebirge.*

26230 to 26235. CASTANEA hybrids.

From Little Silver, N. J. Presented by Dr. W. Van Fleet. Received October, 1909.

26230 and 26231. CASTANEA PUMILA × CRENATA.

"Mostly shrubby in habit; good growers; nuts twice as large as *C. pumila*, often three in a bur; productive, and bears at two to three years from seed. Supposed to be resistant to bark disease." (*Van Fleet.*)

26230. (Seeds.) **26231.** (Plants.)

26232 and 26233. CASTANEA PUMILA × SATIVA (*Paragon* variety).

"Nuts four times as large as those of *C. pumila*, sometimes three in a bur; good growers; arborescent; productive and bears at six years from seed." (*Van Fleet.*)

26232. (Plants.) **26233.** (Seeds.)

26234 and 26235. CASTANEA PUMILA × CRENATA.

"Second generation from self-pollinated seeds; vigorous; not fruited; supposed to be resistant to bark disease." (*Van Fleet.*)

26234. Arborescent plant. **26235.** Shrubby plant.

26236 and 26237. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

From Cedara, Natal, South Africa. Presented by Mr. E. R. Sawer, director, Division of Agriculture and Forestry. Received November 12, 1909.

Seeds of the following:

26236. "Mammoth yellow." **26237.** "Chinese," yellow.

"This is our principal field crop in the Midlands." (*Sawer.*)

26238 to 26240. RUBUS spp.

From Lowdham, Nottinghamshire, England. Purchased from Messrs. J. R. Pearson & Sons, at the request of Mr. Walter T. Swingle. Received November 16, 1909.

Plants of the following:

26238. **Blackberry.**

Parsley leaved. "This is said to be of English origin, supposed to have originated at Handsworth, and is, in the opinion of Messrs. Pearson & Sons, 'far

26238 to 26240—Continued.

26238—Continued.

better than any of the American kinds, and in addition to being a good cropper, it is very ornamental and may be used with good effect for covering wild rockery and rough banks.'" (*Swingle.*)

26239. **Raspberry.**

November Abundance. "This is said to produce 'a good supply of fruit during September and onwards.'" (*Swingle.*)

26240. **Raspberry.**

Superlative. "Said to be a good dessert berry, of red color, large size, and of excellent flavor, readily picked on account of its long stalks." (*Swingle.*)

26241. Brassica oleracea capitata L. **Cabbage.**

From Dalny, Manchuria. Presented by Mr. A. A. Williamson, vice-consul in charge. Received November 15, 1909.

"The Manchurian cabbage is one of the chief articles of diet of the inhabitants of these regions. It is particularly tender, succulent, and well flavored. These are a few of the first seeds, which only ripen in the spring." (*Williamson.*)

26242. Quercus aegilops L. **Oak.**

From Patras, Greece. Presented by Hon. F. B. Wood, British consul. Received November 16, 1909.

Valonia. "The valonia oak derives its name from a Greek word signifying acorn. The valonia produces fully two or three times more than the ordinary oak. The term 'valonia' used commercially does not apply to the acorn but to the cup which contains it, which when ground is used for tanning purposes. The cup is a bright drab color, which it preserves as long as it is kept dry; any dampness injures it, as it then turns black and loses both its strength and value. The more substance or thickness there is in the husk or cup the better it is for commercial purposes.

"Valonia without the acorn (which is only of use for feeding swine, etc.) is worth about £8 to £10 per ton, but the finer quality sometimes fetches £2 or £3 more. In former years the article was worth double the above figures, but chemical and other substitutes used for tanning purposes have brought its value down to a point which scarcely covers the expense of picking and getting ready for shipment.

"The valonia oak flourishes almost exclusively in the Levant; Greece, several islands in the Aegean Sea, Crete, and Asia Minor are its favorite localities. There it thrives in great profusion and in every variety of soil and climate, being affected by neither severe heat nor great cold. In the plains of Elis in soft, heavy, rich soil the valonia displays all its beauties, and in perfect similarity to its congener growing on the barren and stony mountains of Acarnania and Laconia.

"The tree is very beautiful with its great outspreading branches and delicate foliage; it reaches in many instances a height of 60 feet and a girth of 15 feet 3 or 4 feet from the soil. In appearance it resembles the ordinary oak and has many of the latter's characteristics, forming occasionally great distorted boles. It produces the oak apple, and the mistletoe grows on it plentifully.

"The valonia tree can scarcely be called deciduous, for although the leaves attain a withered and brownish look in winter, only a certain proportion are cast before the fresh shoots appear in the early spring.

"The finest valonia forest I know of exists in the province of Achaia, between Patras and Pyrgos. In length it measures some 10 miles and in breadth about 4 or 5. The trees in most instances must be several centuries old.

"The manner of collecting valonia brings one back almost to patriarchal days. The Greek peasantry are for the most part and to a great extent nomadic. In the

26242—Continued.

summer and spring months they retire to their mountain villages, but in winter, driven down by the snows, they descend into the plains bordering the sea and live as squatters. Each family has acquired hereditary rights for years and years to occupy certain portions of the plains, paying a head tax for the cattle which accompany it and having a right to collect valonia in a certain area. The old patriarch of the family, with his wife, sons, daughters, and grandchildren may be seen collecting valonia, for which they pay a tax of 10 per cent in kind to the owner of the property.

"In 1899 the production of valonia in the different localities was as follows: 5,000 tons in Acarnania and Aetolia; 4,100 tons in Laconia and Arcadia; and 900 tons in Achaia. In 1908 the total product of Greece had diminished to 4,000 tons." (*Wood.*)

"Valonia consists of the acorn cups, the best of which contain about 40 per cent of tannin. It is especially serviceable in the production of heavy leathers. The tree has been grown in the vicinity of Paris, where it attained an age of 25 to 28 years before bearing fruit. In the collection of valonia the labor of children and young girls is said to be largely used, the pay of the most skillful amounting to about 30 cents per day." (*W. W. Stockberger.*)

Distribution.—Lower mountain slopes and valleys of Greece, and on the Cyclades. See No. 6833 for previous introduction.

26243. GARCINIA BRASILIENSIS Mart. (?).

From Lawang, Java. Presented by Mr. M. Buysman, Hortus Tenggerensis. Received November 19, 1909.

Distribution.—Found in the woods in the province of Para, in the northern part of Brazil. (Seed.)

26244 and 26245. POLAKOWSKIA TACACO Pittier.

From San José, Costa Rica. Presented by Mr. Ad. Tonduz, through Prof. H. Pittier. Received November 19, 1909.

26244. Small variety having fiber. **26245.** Large variety without fiber.

"A cucurbitaceous plant, the fruit of which is used as a green vegetable. It is a near relative to the chayote, but the fruit is smaller, fusiform, set with stiff spines at the base and of quite a distinct taste. It is one of the primitive foods of the native Indians of Costa Rica, where it grows wild in fresh, shady places of the temperate region, and its use as a vegetable has been readily adopted by the Spanish Costa Ricans. Nowadays the plant is at least semicultivated on the central plateau. To grow it, a whole mature fruit is set in a rich, loose leaf mold with the spiny end up and almost showing at the surface. The vines spread on the ground or on low bushes or supports. The fruits, which are about 2½ inches long and 1½ inches broad, hang from short peduncles and are picked when still green. After taking away the basal spines they are boiled in water, either whole or cut into small pieces, or pickled, or made into preserves. They are also a favorite addition to the native vegetable soups." (*H. Pittier.*)

26246 to 26252. PRUNUS spp. **Cherry.**

From western Hupeh, China. Purchased from Mr. C. S. Sargent, director of the Arnold Arboretum, Jamaica Plain, Mass. Received November 22, 1909.

Plants of the following; notes by Mr. E. H. Wilson:

26246. From Changyang Hsien. "(A. A. No. 3.) A very ornamental tree, attaining a height of 10 to 30 feet. Grows on mountains at an alititude of 2,500 to 3,500 feet. Flowers white."

26246 to 26252—Continued.

26247. From Changyang Hsien. "(A. A. No. 3a.) A very ornamental tree, attaining a height of 10 to 30 feet. Grows on mountains at an altitude of 2,500 to 3,500 feet. Flowers white."

26248. From north and south of Ichang. "(A. A. No. 3b.) A very ornamental tree, attaining a height of 10 to 30 feet. Grows on mountains at an altitude of 2,500 to 3,500 feet. Flowers white."

26249. "(A. A. No. 4.) No description.

26250. From Changyang Hsien. "(A. A. No. 5.) A rare and magnificent species, attaining a height of 35 feet. Grows in glades at an altitude of 3,500 feet. Fruit black."

26251. From Changyang Hsien. "(A. A. No. 7.) A very fine tree, rare, attaining a height of 25 to 35 feet. Grows in woods at an altitude of 3,000 to 3,500 feet. Flowers pink."

26252. From Changyang Hsien. "(A. A. No. 11.) A very common bush species, growing 10 feet high in mountains at an altitude of 2,500 to 3,500 feet. Flowers white and pink."

26253. VICIA FABA L. **Horse bean.**

From Kindred, N. Dak. Presented by Mr. A. P. Hertsgaard. Received November 22, 1909.

"Grown in North Dakota, summer of 1909. Seed originally from Holland. This is said to be called in Holland the pigeon pea." (*Hertsgaard.*)

26256 to 26259. EUCALYPTUS spp.

From Sydney, New South Wales, Australia. Procured from Mr. J. H. Maiden, director and government botanist, Botanic Gardens. Received November 25, 1909.

Seed of each of the following procured for planting on the experimental plantation to be established by the Forest Service, in cooperation with the Bureau of Plant Industry, at Brownsville, Tex.:

26256. EUCALYPTUS SIDEROXYLON A. Cunn.

Distribution.—Australia, in the provinces of New South Wales, Victoria, and South Australia.

26257. EUCALYPTUS GONIOCALYX F. Muell.

Distribution.—Southeastern Australia, from Twofold Bay in New South Wales, to the Buffalo Range in Victoria.

26258. EUCALYPTUS BOTRYOIDES Smith.

Distribution.—Eastern Australia, from Brisbane in Queensland, south through New South Wales, to Victoria.

26259. EUCALYPTUS PAUCIFLORA Sieber.

Distribution.—Common in Tasmania, and in South Australia, Victoria, and New South Wales.

26265. ROSA CANINA L. **Rose.**

From Mexico. Presented by Mr. Harvey C. Stiles, Mexico City, through Mr. P. J. Wester. Received November 26, 1909.

"Seeds of a wild rose, native of the cool, frostless Mexican highlands, but found only where there is constant moisture; it grows luxuriantly, often 12 to 20 feet high, and I have sometimes seen it in gardens, budded or grafted to other sorts of fine roses. It makes an ideal stock, not sprouting like *Manetti*, etc." (*Stiles.*)

26266 and 26267.

From Cape Town, South Africa. Presented by Mr. R. W. Thornton, government agriculturist, Department of Agriculture. Received November 23, 1909.

Seed of the following:

26266. Pentzia incana (Thunb.) Kuntze. "**Karroo bush.**"

Distribution.—Eastern South Africa, from Natal south to Uitenhage, Cape Colony.

26267. Panicum sp.

"This is an indigenous grass which is considered to be one of the best grasses in the Orange River Colony, where in certain parts it is practically the only fodder which the stock have." (*Thornton.*)

26268 and 26269. Passiflora spp.

From Port of Spain, Trinidad. Presented by Dr. E. André. Received November 27, 1909.

Seeds of the following:

26268. Passiflora quadrangularis L. **Granadilla.**

"A plant of South American origin very closely allied to *Passiflora macrocarpa* and *P. alata*, now cultivated in many tropical countries. Its large, greenish-yellow fruit has a thick rind which is sometimes preserved, and the pulp surrounding its seeds, though sometimes insipid, is usually pleasant flavored and is made into cooling drinks and sherbets. The seeds are too large to be swallowed as in the case of the smaller fruited species. This plant is valuable for covering arbors and verandas. The leaves are large, membranaceous, and heart shaped; the large fragrant flowers have red petals alternating with the white sepals, while in the closely allied *P. macrocarpa* both the sepals and petals are purplish. Many species of Passiflora are incorrectly referred to this species." (*W. E. Safford.*)

26269. Passiflora maliformis L. **Sweet cup.**

"This species is frequently cultivated in the West Indies, and on some of the islands it is found wild. The fruit is globose, or apple shaped, and much smaller than the Granadilla or Barbadine (S. P. I. No. 26268). It has a thin shell-like envelope, not soft like that of the waterlemon (*P. laurifolia*) but varying in rigidity. In the specimens sent the shell, which is yellow and marked with numerous white dots, is easily indented, almost like that of *P. ligularis*, but in some varieties it is hard and rigid, even sufficiently so that snuffboxes can be made of it. The pulp is pleasant flavored and slightly acidulous, and the seeds are small enough to swallow. The leaves are simple, entire, and oval or ovate, with linear lanceolate stipules and petioles bearing two glands. The flowers are sweet scented and beautiful, variegated red and white, with blue coronal filaments." (*W. E. Safford.*)

26270 to 26278. Rubus spp.

From western Hupeh, China. Purchased from Prof. C. S. Sargent, director, Arnold Arboretum, Jamaica Plain, Mass. Received November 29, 1909.

Plants of the following; notes by Mr. E. H. Wilson:

26270. Rubus bambusarum Focke.

From north and south of Ichang. "(A. A. No. 48.) A straggling plant; height 10 to 15 feet. Grows in thickets at an elevation of 3,000 to 5,000 feet. Flowers pink. A fine Rubus."

26270 to 26278—Continued.

Distribution.—Bamboo forests on the mountain slopes, at an elevation of 4,000 to 6,000 feet, in the province of Hupeh, central China.

26271. Rubus innominatus S. Moore.

From north and south of Ichang. "(A. A. No. 92.) A shrubby plant; height 3 to 5 feet. Grows in thickets at an elevation of 3,000 to 4,500 feet. Pinkish flowers. Fine, red paniculate fruits."

Distribution.—The valley of the Yangtze River at Kiukiang, in the province of Kiangsi, central China.

26272. Rubus ichangensis Hemsl. and Kuntze.

From north and south of Ichang. "(A. A. No. 663.) A straggling plant. Grows in thickets at an elevation of 2,000 to 4,000 feet. Flowers white. A good thing."

Distribution.—The vicinity of Ichang, province of Hupeh, China.

26273. Rubus parkeri Hance.

From north and south of Ichang. "(A. A. No. 44a.) A straggling plant; height 6 to 15 feet. Grows in glens, etc., up to an elevation of 2,000 feet. Pink flowers, calyx red, very glandular."

Distribution.—The provinces of Hupeh and Szechwan, China.

26274. Rubus lambertianus Ser.

From north and south of Ichang. "(A. A. No. 482.) A spreading plant; height 6 to 10 feet. Grows in thickets at an elevation of 2,000 to 4,000 feet. Whitish flowers. Red fruits."

Distribution.—Kiukiang, in the province of Kiangsi, and along the valley of Lienchu River, in the vicinity of Saingu, province of Kwangtung, central China.

26275. Rubus chroosepalus Focke.

From south of Ichang. "(A. A. No. 80.) A rambling plant; height 7 to 10 feet. Grows in thickets at an elevation of 3,000 to 4,000 feet. Leaves small, cordate, hairy below."

Distribution.—The vicinity of Patung, in the western part of Hupeh.

26276. Rubus conduplicatus Duthie.

From north and south of Ichang. "(A. A. No. 97.) An erect plant; height 6 to 8 feet. Grows in thickets at an elevation of 3,000 to 5,000 feet. Flowers pink. Fruit red, growing in dense clusters."

26277. Rubus coreanus Miq.

From north and south of Ichang. "(A. A. No. 31.) An erect plant; height 6 to 8 feet. Grows on mountains, etc., up to an elevation of 4,000 feet. Flowers purple. Stems white. Ornamental."

Distribution.—The provinces of Kiangsi and Hupeh, in central China, and the islands of the Korean Archipelago.

26278. Rubus hypargyrus Edgew.

From Changlo Hsien. "(A. A. No. 152.) Grows on mountains at an elevation of 3,000 to 4,500 feet. Fruit dark red. Flowers paniculate. Leaves silvery below."

Distribution.—Himalaya Mountains of northeastern India and mountains of central China.

26279 to 26281.

From China. Presented by Rev. T. D. Holmes, Alfred, N. Y. Received November 24, 1909.

Seeds of the following:

26279. ALEURITES FORDII Hemsl. **China wood-oil tree.**

Largest seeds of this variety yet received. See No. 25081 for description.

26280. SAPINDUS MUKOROSSI Gaertn.

"The Chinese use this fruit, just as it is gathered, to wash with. My wife says these soap balls are superior to our soap for washing flannel fabric, in that they prevent shrinking." (*Holmes.*)

Distribution.—Southeastern China, in the provinces of Chekiang, Fukien, Hupeh, and Kwangtung. Also in India, and introduced into Japan.

26281. GYMNOCLADUS CHINENSIS Baill.

"The pods of this tree are used as a soap." (*Holmes.*)

Distribution.—The southeastern part of China, in the provinces of Hupeh, Chekiang, and Kiangsi.

26282. VICIA FABA L. **Horse bean.**

From Cawnpore, United Provinces, India. Presented by Mr. H. M. Leake, economic botanist to government. Received November 29, 1909.

"Seed of the only form of *Vicia faba* grown here. It is a cold-weather crop, sown in October and ripening in March. The unripe pod is used as a vegetable and the ripe seed after soaking and boiling. The stalks are used as fodder for stock, chopped up and mixed with other fodder (e. g., sorghum).

"The plant is grown only for personal consumption. It has, therefore, no market value." (*Leake.*)

26283. PINUS PINCEANA Gordon.

From Mexico. Presented by Mr. Elswood Chaffey, Hacienda de Cedros, Mazapil, Zacatecas, Mexico. Received November 18, 1909.

"Seed from a pine which grows some 50 feet high and as much as 2 feet in diameter." (*Chaffey.*)

Distribution.—Along gulches on the slopes of the great table-land in northeastern Mexico, between 19° and 25° north latitude.

26284 to 26288.

From Tokyo, Japan. Presented by Mr. Albert J. Perkins, who procured them from The Tokyo Plant, Seed and Implement Co. Received November 29, 1909.

Seeds of the following:

26284 to 26287. RAPHANUS SATIVUS L. **Radish.**

26284. *Sakurajima.* See No. 22399 for previous introduction.

26285. *Nerima.* See No. 22397 for previous introduction.

26286. *Takuwan.*

26287. *Miyashige.*

26288. ARALIA CORDATA Thunb. **Udo.**

Kan. For description, see Bulletin 42, Bureau of Plant Industry, Department of Agriculture.

26289 to 26291.

From Kentung, Burma. Presented by Rev. R. Harper, M. D., American Baptist Shan Mission. Received November 29, 1909.

Seeds of the following; notes by Rev. R. Harper:

26289. Stizolobium sp.

"Collected by Captain McGregor. This is a sort of creeper, I believe, very thorny."

26290. Anona squamosa L.

"*Mak au hsa.* This fruit is a favorite in Burma, and if it can be grown in the Southern States ought to command a large market."

26291. Carica papaya L. **Papaw.**

Papaia, from which a digestive extract called papain is made.

26292 and 26293. Stizolobium spp.

From Dharapuram, India. Presented by Rev. George N. Thomssen, Baptla, South India, who procured them from Dr. C. A. Barber, government botanist, Agricultural College, Coimbatore, India. Received November 29, 1909.

Seeds of the following:

26292. "*Punarkkali.*"

26293. (Native name not given.)

"These varieties grow wild in southern India." (*Barber.*)

26294 to 26296. Vicia faba L. **Horse bean.**

Presented by Mr. R. L. Sprague, American consul, Gibraltar, Spain. Received November 29, 1909.

Seeds of the following:

26294. From Mazagan, Morocco.

26295. From Spain.

26296. From Taragona, Spain.

26297. Amygdalus andersonii (Gray) Greene. **Wild peach.**

From Pyramid Lake, Nevada. Presented by Mr. Marsden Manson, San Francisco, Cal. Received December 1, 1909.

Mr. Manson recommends this wild peach as a stock and for hybridizing experiments. See No. 21657 for previous introduction.

Distribution.—California, from Sierra County southward to Inyo County, and in the western part of Nevada.

26298. Anona longiflora S. Watson.

From Altadena, Cal. Presented by Dr. F. Franceschi, Santa Barbara, Cal. Received December 1, 1909.

"Fruit said to compare well in quality with the cherimoyer. The species is hardy and grows quite vigorously at Altadena, Cal. To judge from photographs of fruit, leaves, and seeds, it would seem to be a species intermediate between *Anona cherimola* and *Anona squamosa*, possibly a natural hybrid between these species." (*P. J. Wester.*)

Distribution.—In ravines on the slopes of the Cerro de San Estevan, in the vicinity of Rio Blanco, Mexico. (Seed.)

26299. (Undetermined.) (Scrophulariaceæ.)

From Yosemite Valley, Mariposa County, Cal. Presented by Mr. F. W. McCauley, through Col. G. B. Brackett, pomologist. Received December 1, 1909.

"Seed of a wild plant that grows in this section of the country and seems to be valuable for cattle to feed on. It is a large plant, attaining a height of 3 to 4 feet and growing in the shape of a small tree. It ripens in the latter part of October, coming up the following season from seed. It is at its best for cattle in August, when it is still tender. When driven cattle throng the woods at this season of the year they will go out of their way to munch on this plant; later in the season it becomes hard and woody, and then cattle will only eat the more tender branches of it. This plant grows in light, sandy soil of granitic origin and apparently without moisture; it thrives on steep south hillsides among brush and rocks, also on the mountain top in the pine forests 4,000 feet above sea level. A peculiarity of the plant is that it grows in little patches—here half a dozen plants, and there possibly 50 together; I believe the seed does not spread readily. If this plant could be cultivated with success I believe it would be valuable as a forage plant to be grown without irrigation. It grows well at altitudes as low as 2,000 feet above sea level, where the thermometer stands at 100° and marks as high as 110°." (*McCauley.*)

26300. ROYSTONEA REGIA (H. B. K.) O. F. Cook.

From Nice, France. Presented by Dr. A. Robertson Proschowsky. Received November 27, 1909.

"A variety from Mexico." (*Proschowsky.*)

Distribution.—Common about Cruces, Gorgona, and San Juan, in Panama, and in Cuba, Antigua, and other West Indian islands.

26301. ANDROPOGON HALEPENSIS VIRGATUS Hackel.

From Algiers, Algeria. Presented by Doctor Trabut. Received December 2, 1909.

"This grass is vigorous, but not stoloniferous, and would be interesting for hybridizing with *Sorghum vulgare* [*Andropogon sorghum*]. It is a moderately good forage like Johnson grass, but has the advantage of not stooling. This variety is perennial here and produces many seeds." (*Trabut.*)

Distribution.—Egypt, extending from Alexandria, through Nubia, to the valley of the White Nile, in the Province of Kordofan.

26302 and 26303. VIGNA UNGUICULATA (L.) Walp. **Cowpea.**

From Entebbe, Uganda. Presented by Mr. R. Fyffe, Botanical and Forestry Department. Received December 3, 1909.

Seeds of the following; native names as given by Mr. Fyffe:

26302. Buff seeded. (This number was assigned to three packages of seed which had been mixed in transit. The native names are as follows: "Mpendi Kiriya Mugombere," "Mpendi Kantinti," "Mpendi Bimogoti.")

26303. Black seeded. "Mpendi Luzzige."

26304 to 26329.

From Chile. Received through Mr. José D. Husbands, Limavida (via Molina), Chile, November 9, 1909.

Seeds of the following; notes by Mr. Husbands:

26304 to 26329—Continued.

26304. ACACIA LONGIFOLIA (Andr.) Willd.

"*Aromo.* A grand, yellow-flowered tree, grown in Chile from the time of the Spanish, for ornamental purposes."

Distribution.—A shrub or small tree found throughout Australia and in Tasmania. Used as a street tree in California.

26305. AEXTOXICON PUNCTATUM R. and P.

"In Valdivia and Chiloe this plant is called 'tique' or 'palo muerto;' in the north it is called 'acietunillo' or 'olivillo.' It grows along the coast of Chile from Valparaiso to the island of Chiloe."

26306. ARISTOTELIA MACQUI L'Herit.

"*El Maqui.* This is a valuable wild fruit tree and I believe is capable of improvement. The fruit is abundant, astringent, sweet, and refreshing. In time of fruitage 'chicha de maqui' is highly esteemed as a healthful beverage. It is nonfermented; the fruit is simply mashed and mixed with water and the liquid drawn off and drunk. The fruit juice is similar in color to blackberry juice; it stains whatever it comes in contact with, but it is not indelible. The fruit is gathered in immense quantities and dried for export and domestic uses, especially for coloring wines or imitating them. These seeds are from near Puerto Montt, which is the extreme southern limit of the territory allotted to their growth; they are as good as 'el maqui' of central Chile. The color of the fruit is generally a reddish black; brown, white, and pink fruits are sparsely found in a few localities, but these are different varieties. This tree sometimes attains a height of 30 to 35 feet. Usually it is not more than 12 to 15 feet high and 4 inches in diameter, but I have seen trees 16 inches in diameter. They thrive in dry central Chile, but seek the moisture of the ravines. The tree reminds one of a cherry tree. The wood is not considered. The bark of the new wood is very flexible and is used for making lassos and ropes for use about the farm; also for tying in the vineyards. The ties are strong and last a long time if dampened before using. Birds and foxes are very fond of the fruit and scatter the seeds in a fit state to germinate.

"The juice of the leaves is a splendid remedy for throat diseases and ulcers and has a fame for healing wounds. An infusion of the leaves is employed as a gargle. Reduced to a powder, they serve effectively as a healing ointment. They are also good made into a poultice, especially when placed over the kidneys to calm fevers. The fruit, being a quick, mild acid, and astringent, is often used as a refreshing drink in the sick room and is especially efficacious in fevers; toasted and ground or broken and put into hot water it is a sure remedy against the worst cases of diarrhea, dysentery, and cholera; being perfectly harmless the fruit or decoctions may be eaten or drunk in any quantity. The plant is widely distributed, from always dry, rainless Coquimbo to Chiloe's perpetual moisture."

Distribution.—Along ravines from central Chile to Puerto Veras.

26307 and 26308. AVENA SATIVA L. **Oat.**

26309. BOQUILA TRIFOLIATA (DC.) Decaisne.

"'Voquil blanco,' 'boquila,' and 'pilpil blanco' are the Indian names. It grows along the edges of the woods from the thirty-fifth degree of latitude south to and including the island of Chiloe; it avoids altitudes and seeks the moist lowlands. The fruit is without importance."

26310 and 26311. CHUSQUEA QUILA (Poir.) Kunth. **Bamboo.**

"This seed is from the provinces of Cautin and Malleco, in the vicinities of the volcanos Lonquimai, Llaimi, and Villa Rica. Several small lots from

26304 to 26329—Continued.

26310 and 26311—Continued.

different places are contained in this shipment and may or may not be all of the same variety. They are not of the Valdivia class."

Distribution.—The Chilean coast from Valparaiso to Chiloe.

26312. CITRULLUS VULGARIS Schrad. **Watermelon.**

"A watermelon that was harvested in February and eaten in July."

26313. CUCUMIS melo L. **Muskmelon.**

"A melon that grew without water in the poorest arid soil."

26314 and 26315. EMBOTHRIUM COCCINEUM Forst.

26314. "'Notru,' 'el ciruelillo.' A beautiful, flowering ornamental tree fit for any place. Has bunches of bright crimson flowers in early October and dark-green leaves, which are pale green beneath. It grows in the south up to 22 feet and 12 to 16 inches in diameter. A decoction of the bark or leaves is used to cure glandular affections; infusion or smoke cures dental neuralgia, and is also used to cicatrize wounds."

26315. "'Lirhuerillo.' From the Province of Llanquihue. Useful as a timber tree."

Distribution.—The southern part of Chile.

See Nos. 25491 and 25492 for previous introductions.

26316. EUCRYPHIA CORDIFOLIA Cav.

"North of Valdivia this is called 'Ulmo;' at the south 'Muermo.' An evergreen tree with dense foliage, very beautiful on account of its abundant bunches of beautiful, white, fragrant flowers; it grows 50 feet high and 2 feet in diameter. Its hard wood is tan colored, of good quality for charcoal and bright blazing fuel, extra-durable railroad ties, heavy timbers, planks or boards, casks and vats, furniture, or any inside work; it becomes a darker red from exposure and age. Its wood and bark are highly impregnated with tannic acid. The bark contains about 35 per cent of tannin of great excellence, which quickly tans leather of superior quality and of much flexibility. The tanned product has a clean, light-buff color and an increased weight over the crude skins. The tannin of the wood serves for tanning, but is not used on account of its giving leather a blue cast. Ulmo bark is better than lingue and has been successfully applied in the form of concentrated extracts; its superiority as a tanning compound is of recent knowledge. It flowers in November and December and seeds in March and April."

Distribution.—The region around San Carlos, Chile, and extending south to the island of Chiloe.

See No. 25490 for previous introduction.

26317 and 26318. GEVUINA AVELLANA Molina.

26317. "'*Avellana.*' One of the handsomest trees in the world; its glossy, evergreen leaves, bunches of white, fragrant flowers and crimson nuts all at the same time, and its general symmetrical grace and beauty, make a very impressive sight. It grows in the Cordilleras of south and central Chile to the thirty-fourth degree of latitude and not beyond; is also found in the low coast range of the Cordillera Maritima. These seeds were found growing in latitude 44°; they need to be soaked in water a long time to germinate; they thrive in any soil, dry or wet, high or low lands here, but moist land is best for them. The wood of this tree is tough and elastic, takes a high polish, and is good for furniture."

26304 to 26329—Continued.

26317 and 26318—Continued.

26318. "'*Avellana.*' From the Cordillera of central Chile. Soak the seeds well."

See No. 25611 for previous introduction and distribution.

26319. GREIGIA SPHACELATA (R. and P.) Regel.

"'*Chupones.*' From the mainland in the Province of Llanquihue."

Distribution.—In humid situations about Concepcion, Chile, and south to the province of Llanquihue.

See No. 25476 for previous introduction.

26320. GUNNERA CHILENSIS Lam.

"'*Nalca.*' This grows only in wet places, banks of streams, ravines, etc. It is like a giant pieplant or rhubarb and is very ornamental; it is somewhat different from 'Pangue' (S. P. I. No. 25477); the former is eaten raw after the bark or skin is removed and has an agreeable sweet-acid taste; its juice made into ices is eaten with gusto. A decoction for diarrhea, etc., is made from the roots, which are hard and very astringent; the small quantity of juice which they contain is a valuable, permanent black dye for cloths and is estimable for tanning skins. The new sprouts are much esteemed by the Indians; they call them 'pampancallhue.' Oxen eat the leaves with relish when accustomed to them."

See No. 25477 for previous introduction and distribution.

26321. LAURELIA SEMPERVIRENS (R. & P.) Tul.

"Indian name 'el huahuan.' The evergreen laurel is too well known to need description. The industrial applications, large dimensions and merits of its timber, durability when not exposed to the elements, facility to work, ability to permanently receive any stain, etc., require no comment. It is necessary to cut the tree for lumber when the sap is down. It grows to immense size in the Cordilleran foothills of the south and gradually diminishes in size as it is found north of the river Bio Bio. It has nearly all the medicinal properties of *Laurelia aromatica*, among which are the following: An infusion of the scraped or pounded wood, the leaves or flowers is used to cure pains in the head which are the results of colds; the same and especially an infusion of the leaves is used for affections of the digestive tubes, urinary organs, to combat bronchitis and as baths or lotions to strengthen the nervous system, to alleviate or moderate paralysis, to fumigate the body against spasmodic convulsions; a pomade made of the powdered leaves cures skin diseases. The ground bark being placed in the cavity of a tooth stops the pain; an infusion of the bark is used as a remedy for lockjaw, etc."

Distribution.—Frequent in the woods in the vicinity of Valparaiso, Chile, and south to the island of Chiloe, rising to an elevation of 8,000 feet on the mountain slopes.

26322 and 26323. MAYTENUS BOARIA Molina.

26322. "Large-leaved variety." **26323.** "Small-leaved variety."

"An evergreen forest tree, native name 'el maiten.' A beautiful, fine-leaved, dense, semidrooping, small-limbed, shade tree of rare excellence, growing naturally in a round form up to a height of 12 meters and about 12 inches thick. It naturally seeks the dryest, poorest, arid lowland soils. It has great value as forage for horses and cattle; in times of drought or grass failure, hungry animals are kept alive by breaking a few branches daily and feeding the leaves. The wood is fine grained, hard, elastic, and mostly plain white and pale yellow, some-

26304 to 26329—Continued.

26322 and 26323—Continued.

times with a light pinkish-red cast; some varieties are beautifully veined with red and olive colors. The Araucana Indians use the wood to make their bows."

Distribution.—Dry lowlands along the Chilean coast and south to Patagonia.

See No. 23272 for previous introduction.

26324. NOTHOFAGUS sp.

"'*Rauli.*' A giant forest tree of the greatest industrial value; it may be favorably compared with the American black walnut in respect to its uses and commercial importance. Like the finest pines it is used to make all kinds of sash, doors, blinds, and for every class of furniture, and inside and outside construction; it is durable, easy to work, receives and long retains any paint or stain, admits of the highest class of polish, is tasteless, and is largely used for wine casks, tubs, vats, store fixtures, etc. The wood does not warp, split, fade, or rot. The trunks are long and extra thick, requiring the full capacity of both the upper and lower saws of the mills to cut them through. In my opinion 'rauli' is the most valuable wood in Chile for general uses. Grows only in the provinces of Nuble, Conception, Malleco, and Cautin."

26325. QUILLAJA SAPONARIA Molina.

"'*Quillai.*' It will certainly pay to plant plantations of this valuable tree. The natural source of supply is exhausted. They seek the dry hillsides and foothills, where they thrive in the driest and worst kinds of arid soils."

Distribution.—In the valleys and on the plains at the base of the mountains from Illapel, south to the valleys of the Angol and Levu rivers, Chile.

26326. RHAPHITHAMNUS PARVIFOLIUS Miers.

"In the province of Valdivia this is called 'espino blanco;' further south the Indians call it 'arrayan macho,' 'arrayan de espino,' 'guayun,' and 'repu.' It is an evergreen bush or treelet about 20 feet high, good for live fences and ornament."

Distribution.—The southern part of Chile and the adjacent islands.

26327. SOLANUM sp. **Potato.**

26328. SOPHORA TETRAPTERA J. Mill.

"'*Pelu.*' This treelet of 12 to 15 feet is beautifully ornamental, having abundant bunches of fragrant, yellow flowers, which come in August and September before the leaves appear. The wood is not very thick, but is extra valuable on account of its extreme hardness; it is used for hubs, spokes, plow points, pulleys, cogwheel teeth, pins for sailing boats, ships, etc. It grows between Concepcion on the north and Puerto Montt south, also upon the island of Juan Fernandez, where it is called 'Guayacan.' The scraped wood serves as a stimulant and cathartic. It is also used for chronic rheumatism, gout, syphilis, and cutaneous diseases. Lasts forever in water."

See No. 25479 for previous introduction.

26329. TEPUALIA STIPULARIS Griseb.

"'*Tepu.*' This is a small, beautiful tree, which grows along the coast of Chile from Valdivia to the island of Chiloe, where it forms dense impassable forests; the Indians call these woods 'Tepuales.'

26330 to 26343. THEA SINENSIS L. **Tea.**

From China. Procured by Vice-Consul Nightingale under directions from Mr. S. L. Gracey, American consul at Foochow, at the suggestion of Ambassador

26330 to 26343—Continued.

Rockhill before he left Pekin for St. Petersburg, Russia. Plants received at the Plant Introduction Garden, Chico, Cal., December 1, 1909; seeds received at Washington, D. C., December 6, 1909.

Plants of the following:

26330 to 26332. From the Kienning district.

26330. *Lotus Heart.*

26331. *Water Fairy.*

26332. *Dragon Pool.*

26333 to 26336. From Wuishan district, the cliff-grown teas from River of the Nine Windings.

26333. *White Cock Comb.*

26334. *Great Red Robe.*

26335. *Superior.*

26336. *Dragon Pool.*

Seeds of the following:

26337. *Water Fairy* (parent plant).

26338. *Dragon Pool* (parent plant).

26339. *Dragon Pool.* From Heaven Sauntering Place.

26340. *White Cock Comb* (parent plant).

26341. *Red Robe* (parent plant).

26342. *Red Robe.* From Heaven Heart Temple.

26343. *White Peony* (parent plant).

"The cliff-grown teas are extremely rare and valuable, and I do not believe can be obtained again, as the Chinese are not at all anxious to have the tea of this district become general. The department having for some years past written for seed of the 'Dragon Pool teas,' which I was unable to obtain otherwise, though repeated requests have been made, I sent my vice-consul, Mr. Nightingale, and through the extreme courtesy of the viceroy of Fukien, the magistrate of Chungan, and two mandarin friends, he was allowed to gather seeds and select the plants I send. There is 200 miles of foot journey besides considerable boat trip from Foochow to this district, which involves some expense. The peculiar flavor of these cliff-grown teas is said to come from the soil, and other soil may impart an entirely different flavor to the same plant. The earth about the cliff teas is very sandy and not at all rich. A rich soil they claim is not good for tea, as the plant will grow too high and not remain stunted, as is considered desirable. In this district frost occurs often, and now and then there is light fall of snow, which lasts but a short time. The entire district of the River of the Nine Windings is composed of huge red sandstone cliffs and bowlders, and in the shadow and clefts of these, wherever a little of the sandy soil is found, the tea grows. Other than a little digging about the roots at this season of the year (October), no attention is necessary.

"Some fertilize the plants once or twice a year with night soil; the fertilization is not considered necessary.

"Some plants produce as many as four kinds of tea, according to the size of the leaf and the time of gathering. The teas of this district in order of superiority are 'White Cock Comb,' 'Great Red Robe,' 'Superior,' 'Lotus Heart,' 'Water Fairy,' and 'Dragon Pool.' The White Cock Comb and the Red Robe plants were those growing closest to the original plant. The White Cock Comb is said to be 'the original tea plant and to have fallen from heaven;' twice a year the Chungan magistrate comes to see that it is all right and worship at a neighboring temple. The Dragon Pool tea plants are from a little inclosure back of this temple, where a brother of an emperor in the Sung dynasty retired at one time to raise tea, and which I believe has given rise to the story of the

26330 to 26343—Continued.

'Royal Inclosures.' The 'Special Tea' comes from the Chungan magistrate's private stock. The Kienningfu plants produce an inferior quality of tea from that of the cliff district. These plants may be raised from cuttings in the spring; those of the cliff district by seed only.

"The seeds should be soaked in water twenty-four hours before planting, and then planted in the open to a depth of 5 inches in low mounds 3 feet apart; ridges should be made so the rain runs freely from the mounds. Considerable moisture after planting is not desirable.

"The Dragon Pool seed sent is from the Wuishan district. All the seeds are authentic, as Mr. Nightingale gathered them personally." (*Extract from letter dated October 25, 1909, written by Consul Gracey to Mr. George S. Baker, United States dispatch agent, San Francisco, Cal.*)

26344 to 26352. ROSA spp. **Rose.**

From Woods Hole, Mass. Presented by Mr. M. H. Walsh. Received December 2, 1909.

Plants of the following Rambler roses; descriptive notes by Mr. Walsh:

26344. "*Kalmia* is a beautiful light Kalmia formed and colored flower, single."

26345. "*Bonnie Belle* is carmine and pink, single."

26346. "*Delight*, bright red."

26347. "*La Fiamma*, single; intense crimson, with white center."

26348. "*Coquina*, as its name denotes, is shell color."

26349. "*Milky Way*, single, white, large flower; an improved wichuriana."

26350. "*Lady Blanche*, double white wichuriana hybrid; very dark, glossy foliage; flowers borne in clusters similar to Lady Gay. This variety is deliciously fragrant."

26351. "*Excelsa* is double, crimson maroon, with tips of petals fiery scarlet; this will rank as one of the best."

26352. "*Jessica*, a climbing variety, large glossy foliage; large, double flower, cotton white, fragrant; a valuable acquisition."

26353. METTERNICHIA WERCKLEI K. Schum.

From San Jose, Costa Rica. Presented by Mr. Ad. Tonduz. Received December 4, 1909.

"Fleshy roots of what Mr. Carlos Wercklé calls the 'edible tuber' of *Metternichia wercklei* K. Schum. (Solanaceæ); he experimented with eating these pseudotubercles and found them agreeable and without any poisonous principle. *Metternichia wercklei* grows in the high plateaus of La Palma, near San Jose, at 5,000 feet altitude. It is sometimes a branching bush, 7 to 10 feet high, which grows in the ground, and sometimes a semiepiphyte which grows in rotted trunks of trees or in a hollow of some large tree. Mr. Wercklé says that this bush can be propagated very easily by means of pieces of roots." (*Tonduz.*)

26354. CRATAEGUS AZAROLUS L.

From Acre, Palestine. Presented by Miss Rifka Aaronsohn, Zichron-Jacob, near Haifa, Palestine. Received October 19, 1909.

"Seed of the large, red-fruited variety." (*Aaronsohn.*)

See No. 26116 for description.

26355. POPULUS LASIOCARPA Oliver.

From Chelsea, London, England. Purchased from Messrs. James Veitch & Sons. Received December 8, 1909.

"The ovate cordate leaves of this new poplar are extremely large and attractive, measuring 10 to 12 inches in width. They are bright green in color, whilst the petiole, midrib, and principal veins are of a rich red hue. The tree in central China attains a height of 15 to 40 feet and should prove a valuable addition to our ornamental deciduous trees." (*Veitch & Sons.*)

Distribution.—Central China, in the provinces of Hupeh and Szechwan.

26356 to 26362.

From Malkapur, Berar, India. Presented by Mr. A. S. Dhavale. Received November 29, 1909.

Seeds of the following; quoted native names as given by Mr. Dhavale:

26356. CROTALARIA JUNCEA L.
"*Boru.*"

Distribution.—Plains of India from the Himalayas to Ceylon, the Malayan Islands, and Australia. Cultivated for fiber.

26357. DOLICHOS BIFLORUS L.
"*Kulitha.*"

26358. DOLICHOS LABLAB L. **Bonavist bean.**
"*Val.*"

26359. GUIZOTIA ABYSSINICA (L.) H. Cass.
"*Karala.*"

26360. PHASEOLUS MAX L.
"*Urid.*"

26361. PHASEOLUS RADIATUS L.
"*Mug.*"

26362. VIGNA CATJANG (Burm.) Walp.
"*Chavali.*" Brown eye, small.

26363 to 26385. GARCINIA MANGOSTANA L. **Mangosteen.**

Grown at the United States Department of Agriculture greenhouse, Washington, D. C., numbered December 17, 1909.

"These seedlings were raised from S. P. I. No. 21276, received through Mr. H. F. Macmillan, Royal Botanic Gardens, Peradeniya, Ceylon, August 22, 1907. The seedlings were inarched to 4-year-old plants of *Garcinia tinctoria* (DC.) W. F. Wight (*G. xanthochymus*), S. P. I. No. 11788, raised from seeds obtained from Dr. John C. Willis, director of the Royal Botanic Gardens, Peradeniya, Ceylon, October 31, 1904. *G. tinctoria* was used as a nurse plant to which the seedlings of the mangosteen were inarched. Since the unions were effected the mangosteens have made splendid growth and this method promises to be the best one so far as my experimental work in the propagation of the mangosteen has gone. It has been deemed best to give each of these inarched plants a separate S. P. I. number, so that they will not be confused with other mangosteens worked by different methods." (*G. W. Oliver.*)

26386. PUNICA GRANATUM L. **Pomegranate.**

From Tripoli, in Barbary, North Africa. Forwarded by the American vice-consul, at the request of Mr. William Coffin, American consul, who presented them to the Department. Received December 10, 1909.

26387 and 26388.

From Georgetown, Demarara, British Guiana. Presented by Mr. F. A. Stockdale, assistant director and government botanist, Science and Agriculture Department, Botanic Gardens. Received December 10 and 11, 1909.

Seeds of the following palms:

26387. ATTALEA COHUNE Mart.

See No. 1970 for description.

Distribution.—Honduras, and the northeastern part of South America.

26388. COPERNICIA TECTORUM (H. B. K.) Mart. (?)

Distribution.—The valley of the Orinoco River, in South America.

26389 to 26397. ZEA MAYS L. **Corn.**

From Hamburg, Germany. Purchased from Mr. Albert Schenkel, 47 Rosenstrasse. Received December 10, 1909.

Seeds of each of the following; names of varieties as catalogued:

26389. ZEA ATROPURPUREA.

26390. ZEA CARAGUA.

26391. ZEA GRACILLIMA VARIEGATA.

26392. ZEA GRACILLIMA VARIEGATA *gigantea*.

26393. ZEA GRACILLIMA ZEBRINA AUREA.

26394. ZEA JAPONICA, foliage variegated.

26395. ZEA JAPONICA GIGANTEA QUADRICOLOR.

26396. ZEA sp. Rissen mais von Peru.

26397. ZEA TUNICATA, foliage variegated.

The above were purchased for the experiments of Mr. G. N. Collins, assistant botanist, Bionomic Investigations, this Department.

26398. CITRUS AURANTIUM SINENSIS L. **Orange.**

From Toliman Barranca, Hidalgo, Mexico. Presented by Mr. Jorge J. White, Zimapan, Mexico. Received December 15, 1909.

"Cuttings of an orange that retails for 10 centavos each in Mexico City; it is small and extremely sweet, and I believe with care will make a fancy shipping orange. The barranca where they grow was settled by the Spanish padres, who, I believe, introduced the orange; owing to neglect by the Indians, who own all the trees, which are now very few, I suppose that the fruit has deteriorated, but careful cultivation and perhaps crossing might give a remarkably fine orange.

"The winters here are very mild; the soil, generally speaking, is very poor and full of gravel, and is also thin, not exceeding a meter in thickness; underlying the soil is the usual detritus—coarse bowlders—found in the beds of mountain streams. The elevation is about 4,000 feet above sea level." (*White.*)

26399 to 26406. VIGNA UNGUICULATA (L.) Walp. **Cowpea.**

From Mount Selinda, Rhodesia, South Africa.

Presented by Mr. C. C. Fuller, through Mr. W. L. Thompson, M. D. Received November 27, 1909.

Seeds of the following, with descriptions of same:

26399. Small, black.

26400. Large, black.

26401. Small, speckled.

26402. Large, speckled.

26403. Maroon.

26404. Small, buff.

26405. Large, buff.

26406. Cloudy violet and buff.

26408. GOSSYPIUM HIRSUTUM L. **Cotton.**

From Northern Arabia. Presented by Dr. Arthur K. Bennett, Arabian Mission, Busrah, Persian Gulf, via Bombay. Received November 20, 1909.

"Seed of a cotton which I found while traveling across northern Arabia. The women were weaving a light-brown cloth from this kind of cotton, and they say it is bigger and better than the white." (*Bennett.*)

26411. IPOMOEA SINUATA Ortega.

From Iguala, Mexico. Collected by Dr. David Griffiths. Received December 23, 1909.

"Seeds of a native ipomœaceous vine which climbs over shrubs in the valley of Iguala, Mexico. The vine itself is a handsome thing. I have not seen the flowers." (*Griffiths.*)

26412. CARYOPHYLLUS MALACCENSIS (L.) Stokes. **Large rose-apple.**

From Honolulu, Hawaii. Presented by Mr. J. E. Higgins, horticulturist, Hawaii Experiment Station. Received December 16, 1909.

"The mountain-apple, as it is locally known in Hawaii, is a very beautiful fruit of a very dark red color when at its best. It is about the size of a small pear and is of mild, rather pleasing flavor. The tree grows to a height of 40 or 50 feet in the wild condition in the mountains and moist gulches, and bears fruit freely. The usual season is from June to September. It is probable that some interesting results would be obtained by the crossing of this species with some of the more highly flavored species of Eugenia, such as *E. michelii* (=*E. uniflora*)." (*Higgins.*)

Distribution.—Throughout the Polynesian islands; varieties in cultivation in Bengal and Burma.

26413. PSIDIUM LAURIFOLIUM Berg.

From Port of Spain, Trinidad. Presented by Mr. F. Evans, acting superintendent, Botanical Department, Department of Agriculture. Received December 10, 1909.

"Jelly made from this fruit has been found to be of considerable value, from the fact that by its agreeable acidity it is quite distinct in flavor from the ordinary guava jelly made from *Psidium guajava* and *P. polycarpum*. It is also said that it 'jellies' much quicker than the common West India guava.

"It is a plant, therefore, which is likely to become widely distributed on account of its usefulness. The jelly, with soda and ice, makes an excellent 'soft' or 'cool' drink equal to or better than any of the ordinary fruit sirups." (*Extract from Bulletin 57, Trinidad Botanical Department, January, 1908.*)

Distribution.—The vicinity of Masaya, near the Pacific coast of Nicaragua.

26414 to 26418. CITRULLUS VULGARIS Schrad. **Watermelon.**

From Salisbury, Md. Grown by Mr. W. F. Allen; presented through Prof. W. W. Tracy. Received December 15, 1909.

Seeds of the following selections made from the Roumanian watermelons received through Consul Knowles; notes by Mr. Allen:

26414. Rind nearly white; yellow flesh; reddish-brown seeds.

26415. Striped rind; red meat; reddish-brown seeds.

26416. Rind nearly white; red flesh; reddish-brown seeds.

26414 to 26418—Continued.

26417. Striped rind; red flesh; black seeds.

26418. Rind nearly white; red flesh; small reddish-brown seeds. This variety was quite uniform, there being only one type; grown from the second lot of S. P. I. No. 22658, received May 14.

26421 to 26423.

From Hwai Yuan, via Nanking, China. Presented by Mr. Samuel Cochran, American Presbyterian Mission. Received October 15, 1909.

Seeds of the following; notes and native names by Mr. Cochran:

26421. CITRULLUS VULGARIS Schrad. **Watermelon.**

"Hwang jang hsi kwa," yellow fleshed.

26422 and 26423. BRASSICA PEKINENSIS (Lour.) Skeels. **Pe tsai cabbage.**

26422. *T'ang pei ts'ai* (soup white vegetable).

Planted in spring, summer, and autumn by sowing thickly on freshly cultivated soil and then raking in. Ready for use in 20 to 30 days. Eaten boiled. It is also sometimes transplanted from the beds sown as above into rows, each bunch being a foot or so apart. It then grows into large, thick-stalked bunches which are pickled and eaten during the entire year. It is gathered at first hoarfrost when grown in this way, as the first frost kills it.

26423. *P'iao pei ts'ai* (dipper white vegetable).

So called from the shape of the leaf. Sown in beds in August and transplanted into rows in bunches, each clump being separate. It is transplanted in September or early October, and is ripe when snow falls; it continues to ripen through the winter in spite of frost and snow, but its quality is improved by being covered with straw.

26424 to 26439.

Procured by Mr. A. J. Perkins, of the firm of Jackson & Perkins, Newark, N. J., while making a trip through Japan. Received December 8, 1909.

Seeds of the following obtained in Japan, unless otherwise noted; descriptive notes by Mr. Perkins:

26424. AKEBIA LOBATA Decaisne.

A vine from which baskets are made at Aomori, Japan. It is used as an ornamental in the United States. Seeds of an especially large-fruited variety as well as a common kind are contained in this lot.

See No. 24744 for previous introduction and distribution.

26425. CITRUS sp. **Orange.**

"*Yusu.*" A Japanese sour orange, round and flat. Used as lemon and as a stock.

26426. CITRUS TRIFOLIATA L.

Seed from a tree in the Yokohama Nursery Co.'s grounds.

26427 and 26428. CUCURBITA PEPO L. **Squash.**

26427. "*Chirimen.*" Has a rough, knotted exterior; named after a kind of silk having rough knots in its texture.

26428. "*Kikuza.*" Has a smooth exterior, as its name signifies.

Both these kinds are said to have yellow meat 1½ inches thick which is of fine flavor when boiled.

26424 to 26439—Continued.

26429. DIOSPYROS KAKI L. f. **Persimmon.**

These seeds are from nonastringent fruit.

26430. EUONYMUS OXYPHYLLUS Miq.

From Botanical Gardens, Sapporo, Japan.

Distribution.—The vicinity of Port Chushan, Korea; also Japan.

26431. FEDIA SCABIOSAEFOLIA (Fisch.) Trev.

"*Omineshi.*" An ornamental herbaceous perennial from Morioka, Japan.

Distribution.—The provinces of Chihli, Shingking, Kiangsu, Chekiang, Fukien, Hupeh, and Kwangtung, in China; Korea, and Japan.

26432. FIRMIANA SIMPLEX (L.) W. F. Wight

"*Ao giri.*" From Morioka, Japan.

26433. HORDEUM DISTICHON NUDUM L. **Naked barley.**

"*Shiratama*" (white grain). Winter barley, procured by Prof. Gentau Tamada, from Morioka, Japan.

26434. HORDEUM VULGARE COELESTE L. **Barley.**

"*Marumi*" (round seed). From Messrs. Aizawa & Co., Sapporo, Japan.

26435 and 26436. PERILLA NANKINENSIS (Lour.) Decais.

26435. White or green leaved variety.

26436. Purple-leaved variety.

Known in Japan as "Shiso;" edible, being used as a condiment in cooking and to color pickles in combination with *Prunus mume*.

Distribution.—The provinces of Kiangsi and Szechwan, China; also Japan.

26437. PITHECOLOBIUM DULCE (Roxb.) Benth.

From Kapiolani Park, Honolulu, Hawaii. See No. 23457 for description.

26438. SESAMUM ORIENTALE L. **Sesame.**

Black seeded.

26439. ZANTHOXYLUM PIPERITUM (L.) DC.

"*San-sho.*" A condiment, purchased in Hakodate.

Distribution.—Provinces of Shensi and Shantung, eastern China; the island of Port Hamilton, in the Korean Archipelago; and the woods on the mountain slopes in central Japan.

26440. ANONA LONGIFLORA S. Watson.

From Altadena, Cal. Presented by Mr. F. O. Popenoe. Received December 20, 1909.

Budwood taken from the tree which produced the seed sent in under S. P. I. No. 26298, which see for description.

26441. ANONA sp.

From San Salvador, Salvador, Central America. Presented by Mr. H. F. Schultz, Ancon, Canal Zone, Panama. Received November 23, 1908.

"I obtained the seed of this Anona from a friend of mine whom I met in Panama and who mailed it to me from San Salvador, Salvador. When I saw him at Ancon he spoke very highly of these 'sugar apples' of his country; beyond his verbal descriptions, which were very general, I have no guide regarding the identity of the species." (*Schultz.*)

26442 to 26456.

The following seeds were turned over to this office by Dr. R. H. True, physiologist in charge of Drug-Plant, Poisonous-Plant, Physiological, and Fermentation Investigations, for distribution, December 27, 1909.

26442. ATROPA BELLADONNA L. **Belladonna.**

26443. CALENDULA OFFICINALIS L. **Pot marigold.**

26444. CANNABIS SATIVA L. **Hemp.**

26445. CARUM CARVI L. **Caraway.**

26446. NEPETA CATARIA L. **Catnip.**

26447. CONIUM MACULATUM L. **Conium.**

26448. CORIANDRUM SATIVUM L. **Coriander.**

26449. DIGITALIS PURPUREA L. **Foxglove.**

26450. FOENICULUM VULGARE Hill. **Fennel.**

26451. INULA HELENIUM L. **Elecampane.**

26452. LOBELIA INFLATA L. **Indian tobacco.**

26453. ALTHAEA OFFICINALIS L. **Marshmallow.**

26454. MONARDA FISTULOSA L. **Horsemint.**

26455. SPIGELIA MARILANDICA L. **Maryland pinkroot.**

26456. SESAMUM ORIENTALE L. **Sesame.**

White seeded.

26457 to 26459. HORDEUM spp. **Hull-less barley.**

From Nara, Japan. Procured by Mr. A. J. Perkins, from Dr. G. Nakamura, director, Experiment Station. Received December 22, 1909.

Seeds of the following; descriptive notes by Mr. Perkins:

26457. "*Zun-paku-mugi.*" Pure white naked barley; produces 1.751 koko per tau (one-fourth acre) and is hardy.

26458. "*Yane-hadake.*" This is hardy and produces more than 1 koko per tau.

26459. "*Kama-ore.*" Produces 2.005 koko per tau and is useful for both grain and straw.

26460. CITRUS TRIFOLIATA L.

From Tokyo, Japan. Presented by Prof. Y. Kozai, director, Imperial Agricultural Experiment Station. Received December 27, 1909.

Large seeded. To be used for stocks.

26462 to 26465. TRIFOLIUM SUBROTUNDUM Steud. & Hochst.

From Adis Ababa, Abyssinia. Presented by Mr. Hoffman Philip, American minister. Received December 20, 1909.

Seeds from plants found in a shady garden; descriptive notes by Mr. Philip:

26462. Most profuse variety; full flower; large leaves light in center; grows to height of about 1½ feet.

26463. Full flower; small leaves; grows to height of about 1 foot; not very profuse.

26464. Grows to height of about 3 feet; not very erect; large leaves, all one color.

26465. Grows to height of about 2 feet; not very erect; very narrow leaf."

26470. SPONDIAS DULCIS Forst. **We fruit.**

From Monrovia, Liberia. Presented by Mr. E. L. Parker, commissioner of agriculture. Received December 30, 1909.

"The we fruit (pronounced vee) or Tahiti-apple. The tree is of rapid growth, highly ornamental, and attains a height of 50 feet in its native habitat. The golden-yellow fruits, about 2 to 3 inches in diameter, are produced in loose clusters. The brownish-yellow flesh partakes of the flavor of a pineapple and most people become very fond of the fruit when once accustomed to it.

"The we fruit is indigenous to the Society Islands and is now disseminated to most tropical countries. In Florida, where it has fruited in Miami and Lemon City for at least four years, it appears well adapted to well-drained land underlaid with coral limestone. It is a trifle less hardy than the mango, to which plant the we fruit is related." (*P. J. Wester.*)

Distribution.—Cultivated throughout the Tropics; probably native in the Polynesian islands.

PUBLICATION OF A NEW NAME.

26078. CAPRIOLA INCOMPLETA (Nees) Skeels.

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